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CHARLES C. ADAMS, DIRECTOR

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INSECTS AND HEALTH

By

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Museum*

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INSECTS AND HEALTH

INTRODUCTION

Insects as Disease Carriers

The fact that insects are important carriers of such diseases as typhoid fever, cholera, other affections of the digestive tract, and Egyptian ophthalmia, and sole carriers of malaria, yellow fever, plague, typhus, trench fever, relapsing fever, filariasis, dengue or breakbone fever, and sleeping sickness, indicates the effect they may have upon human health and happiness.

The foregoing enumeration of serious human infections deserves more than a passing thought. The frightful mortality from plague in the Middle Ages and during recent years in India, taken in connection with the fact that it appeared recently at several American ports, indicates a real menace to the welfare of our people unless the early detection and rigorous repressive measures characteristic of these American outbreaks continue to prevail. The ravages of cholera and typhus, in particular, are so well known that further exposition is unnecessary. The deadly yellow fever, the terror up to recent years of our southern ports, has been known in both Philadelphia and New York City, though not in recent years. A little laxity in sanitation is all that is necessary for the reestablishment of certain of these infections.

The blight laid upon malarial regions is something not adequately appreciated in this country. This disease affects some three million people in the Southern States and causes annually economic losses estimated at one hundred million dollars. Dr H. R. Carter states that the loss from malaria in the South is beyond comparison greater than that caused by any other disease or even by two or three other diseases combined.

The estimated mortality from malaria in the United States during 1916 was fifteen thousand and the approximate number of cases was placed at one million. Each death from malaria means some 2000 to 4000 sick days with its accompanying economic losses. Dr L. O. Howard, chief of the Federal Bureau of Entomology, estimates that one-fourth of the productive capacity is lost in the case of individuals suffering from malaria. A concrete picture of conditions resulted from the work conducted by Professor D. L. Van Dine a few years ago. His studies on a plantation of 1800 acres supporting 74 families

or 299 individuals showed that there was a loss through malaria of \$2200 on account of sickness, and a total of \$4300 through inefficiency caused by this infection. This obtained in a typical area in Madison Parish, La. An inspiring and most readable account of developments in medical entomology may be found in: *A Fifty-Year Sketch of Medical Entomology*, by L. O. Howard (cf Howard 1923).

Mosquito control work was conducted in 11 Southern States and in seven of these approximately 200,000 cases of malaria were reported to state health departments.

The possibilities in mosquito control are shown by the work in 10 New Jersey counties in 1923. A total of \$300,000 was expended for the protection of two million people, at an average per capita cost of 15 cents. This very low average is possible only in thickly settled areas.

Insects and Comfort

Insects also affect human health and comfort seriously in the annoyance and irritation they may cause, as for example the buzzing and disturbing action of the house fly, the humming and biting of various mosquitoes and in the open the sometimes unbearable attacks by hordes of black flies. In all of these cases the injury or annoyance from one insect is comparatively small, although the result is very different when these attacks continue over considerable periods and there are hosts of tiny persecutors. Occasionally conditions arise which make rest nearly impossible, and in not a few cases there is a material lowering of bodily vigor from continued insect attacks. The very severe irritation produced by the drifting hairs of the brown tail moth in New England localities where this introduced insect was very abundant is one of the special cases deserving mention.

Types of Insect Carriers

It is important to note at the outset that carrying diseases is largely involuntary with most insects, and furthermore it should be clearly recognized that they must first gain access to some infection before they are able to pass it along.

There are two methods of disease carrying commonly found among insects. In a number of instances they serve as purely mechanical agents, as in the case of the house fly. This insect may carry diseases upon its hairy, filthy body, may eject infected saliva or even deposit deadly infections with its dejecta upon human food.

A number of insects serve as alternate hosts for disease organisms, as in the case of the malarial mosquito. The parasites in such a

case undergo definite transformations within the body of the insect and a certain period must elapse, some 10 or 12 days, between the time the mosquito feeds upon an infected person and its successfully conveying the infection to another individual.

Factors Restricting Infection

The chances of spreading disease in either instance are proportional to the opportunities for infection and the frequency of contact with human beings. It therefore follows that the insects more commonly associated with man, other things being equal, are most likely to be disease carriers.

Four important factors are involved in the transmission of insect-borne diseases, namely: infection, carriers, non-immunes, and breadth of contact. It is obvious that diseases can not be disseminated without a source of infection and that a carrier must be available.

The part non-immunity plays is frequently overlooked. Residence in an area where an infection commonly occurs very frequently results in light attacks early in life and large if not complete immunity thereafter. Europeans resident in China, for example, must be much more careful of their diet than natives, because the latter have developed a certain degree of immunity to intestinal infections. The native residents of malarial sections are also comparatively free from this disease, although if a few with the infection in a latent condition in the blood move to an area where there is a high percentage of non-immunes, this change is very likely to be followed by an explosive outbreak of malaria.

The last mentioned, namely, breadth of contact, is more important than may appear at first sight. A very narrow contact, for example, means only occasional cases here and there, whereas a broad contact may result in larger epidemics, sometimes sweeping away a very considerable proportion of the population, as in the case of the plague in the Middle Ages and sleeping sickness during recent years in equatorial Africa. The breadth of contact was really the factor which prevented the French from building the Panama canal. There are in most sections of the world germs of insect-borne diseases, carriers and non-immunes. The reason there is not more illness from these causes is due to the narrowness of the contact. For example, it was found during recent years in Greenville, S. C., that good privies afforded an efficient control of typhoid fever in spite of there being 1200 shallow wells.

The control or prevention of infections conveyed by insects therefore resolves itself in a general way at least into the maintenance of sanitary measures. The first care should be to eliminate opportunities for insect infection and the second to guard against infected insects.

The modern trend toward sanitary conveniences in dwellings and other city structures has eliminated many opportunities for insects to gain access to pathogenic matter, and yet careful examinations of sections in many cities would show that this supposed immunity is more apparent than real. A careful survey of alleys, backyards and unoccupied lots within city limits would reveal many hitherto ignored opportunities for insect infection. If it is granted that wastes from the human body are most prolific sources for infection, then in the case of smaller villages and rural districts the sanitary conditions in relation to these latter remain about as they were many years ago. There is need of careful reexamination of these conditions and the establishment of methods which will reduce to a very considerable extent the possibilities of insect infection.

It should be generally recognized that most insects troublesome about dwellings find attractive conditions in the near vicinity and rarely travel long distances. In other words, most communities seriously troubled with flies, mosquitoes or other pests are usually providing very satisfactory, nearby breeding places for these insects. The realization of this should make it comparatively easy to modify practices in such a way as to reduce greatly the numbers of the pests. For example, the rather general replacement of horses by automobiles in the last 20 years has produced, without any special care in other directions, a very great decrease in the fly population of many communities. Experience in many localities, particularly along the Atlantic seaboard, has abundantly demonstrated the possibility of eliminating the mosquito nuisance even under most adverse conditions and without excessive expenditures.

Causes of Insect-borne Diseases

Most if not all the diseases affecting man and carried by insects are caused by minute microscopic or ultramicroscopic plant and animal organisms, many of the latter belonging to a large group of one-celled animals known as Protozoa. Certain of these minute organisms approach each other so closely that it is not always easy to distinguish between those belonging with the plants and others which should be classed as animals. Some live in the intestinal tract and others occur in the blood stream of man.

Three well-known diseases, namely, tuberculosis, typhoid fever and Asiatic cholera are all caused by minute plant organisms known respectively as *Bacillus tuberculosis* Koch, *B. typhosus* Eberth, and *Spirillum cholerae* Koch. All are classed with the fungi, and insects such as the house fly serve simply as mechanical carriers. The organism producing diphtheria, *Bacillus diphtheriae* Klebs, also belongs here and experimental data have shown that the bacilli may be ingested and disseminated by flies. Anthrax, produced by *Bacterium anthracis* Dav., is carried by flies, most often probably by biting flies.

There are considerable series of minute Protozoa and other animals which produce diseases in man. The *Entamoeba histolytica* Schaud. is a minute amoebalike organism which has been definitely associated with dysentery.

The flagellates, so designated because of the long, whiplike locomotor organs, produce some very serious infections. They are possibly best known through the Trypanosomes, mostly African and South American, and are the recognized causes of the sleeping sickness of man and the nagana of animals in Africa, and the chagas fever of South America. These parasites occur in the blood of many vertebrates and may be found in the digestive tract of insects. A number of Trypanosomes are known. The related Leishmanias are intracellular parasites in the human host and produce such diseases as kala-azar, oriental sore and in South America the hideous espundia. It is believed that the Leishmania diseases of man and other animals have developed from organisms which normally occur in insects and have now become adapted to existence in vertebrate hosts.

The Spirochaetes represent another group of these minute flagellate animal parasites. They are long, wavy, threadlike organisms which establish themselves in the blood and produce relapsing fever, yaws, infantile jaundice, yellow fever and some less important affections.

Another important group, the Sporozoa, so named because they are spore-producing animals, are of importance in this connection because therewith are classed malarial organisms known as *Plasmodium malariae* Lav., *P. vivax* Grassi and Fel., and *P. falciparum* Welsh, the causes respectively of quartan, benign tertian, and malignant tertian malaria. These forms pass through a definite cycle of changes within the mosquito as well as in the vertebrate host and in the latter cause periodic, systemic disturbances.

The round worms or nematodes are represented in the list of insect-carried disease producing animals by *Filaria bancrofti* Cobb. These are very long, slender, microscopic worms, the females some three or four inches in length and hardly larger than a horse hair. They live in the blood, being abundant at night and scarcely evident during the daytime. This parasite is carried by the bite of one or more mosquitoes, the most serious effect being the abnormal development of portions of the body associated with elephantiasis and due to obstruction of the lymphatics by the filaria. The loa worm, *Filaria loa* Cobb., also belongs in this group. There are many species of nematodes, a number infesting various insects, a very minute one coming to notice recently as the cause of a creeping eruption in Florida.

Insect Poison and Stings

It is well known that certain insects may cause considerable pain and even endanger life by poisonous bites or stings, and on this account there is a somewhat general fear of insects.

Stinging bees and wasps. Honeybees, bumblebees, hornets (see fig. 1) and wasps are among the better known of the stinging insects. A sting is usually not followed by serious consequences unless a particularly vulnerable place is attacked. Numerous stings are usually accompanied by extensive swelling and may prove serious. The horse is especially susceptible to bee stings. Practically all the pain in these cases is caused by a secretion from poison glands, the sharp sting or ovipositor serving simply as an injecting organ.

A report has recently been published (Von Geldern 1927, p. 302) of numbness and systemic disturbances following the supposed sting of a small parasitic wasp, *Epyris* sp., in some cases, the sting being followed by marked prostration, weakness and sweating lasting for about half an hour. There is some question as to the facts of the case and it is mentioned here simply as a possibility which may well be kept in mind.

Poisonous bugs. There is a somewhat long series of insects with mouth parts modified into sucking organs which are capable of inflicting a poisonous bite, the latter caused by the injection of a poison when the mouth parts are inserted. These insects very rarely attack man unless molested, a notable exception possibly being certain assassin bugs, such as *Reduvius personatus* Linn., widely known in 1899 as the "Kissing-bug" and even here there is a possibility that in many cases there was an unconscious holding or confining of the bug at the time of attack. This insect has a very

painful bite which compares well with the sting of a honeybee or bumblebee. The giant water bugs and the back-swimmers, *Noto-nectas*, are also capable of inflicting a very painful stinglike bite.

Nettling caterpillars. A number of caterpillars possess nettling or urticating spines capable of producing severe pain and even extensive inflammation under certain conditions. Fortunately most of these are comparatively rare, a marked exception being the caterpillars of the brown-tail moth, *Euproctis chrysorrhoea* Linn., in southeastern New England during the periods when it was so extremely abundant. The hairs of this caterpillar are so light that they drift in the air, and brown-tail rash, as it is locally called, may be caused by the hairs drifting from caterpillars or even cocoons on a badly infested tree. If one of these caterpillars drops upon the exposed skin, there is very likely to be serious local inflammation. Individuals working with these caterpillars must take great care if they would avoid painful irritations and possibly serious results. Even the respiratory tracts may be affected by inhaling the smaller poisonous hairs. Fortunately the numbers of the brown-tail moth have been greatly reduced in recent years and we hear comparatively little of brown-tail rash.

There are a number of native stinging caterpillars, such as the hairy, apparently innocent looking caterpillar of the flannel moth, *Lagoa crispata* Pack. The larva rests upon a leaf and appears more like a bunch of harmless hairs than a living insect capable of inflicting a sting comparable to that of the bee. The closely related saddle-back caterpillar, *Sibine stimulea* Clem., easily recognized by its rich browns, greens and yellows and the conspicuous spiny tubercles, has similar properties. The io caterpillar, *Automeris io* Fabr., a greenish, spiny creature some two inches long when full grown, feeds in clusters upon a variety of trees, cherry being a favorite, is another of these stinging forms. Its brilliant colors and armature generally lead to its avoidance.

Poisonous spiders. Most spiders native to the northern part of the United States are harmless, a marked exception being the black widow, *Latrodectus mactans*, a moderate-sized species, which under favorable conditions inflicts a very severe and dangerous bite quickly followed by shooting pains, cold sweat and great agony. The tarantula of the Southwest, a large spider, is capable of inflicting a poisonous bite which under some conditions may be followed by serious consequences. Crab spiders, often found on bananas, are reported as quite harmless, though most persons have a marked aversion to handling them.

Treatment for Stings

The best treatment for insect stings and nettling is the application of cooling lotions, such as weak solutions of ammonia or even a paste of baking soda. One of the best used in earlier years in the brown-tail moth section consists of one-half dram of carbolic acid, one-half ounce of zinc oxide and eight ounces of lime water. Shake this thoroughly and rub well into the affected parts.

HOUSE FLY, *Musca domestica* Linn.

The house fly (see fig. 2) is easily recognized as being the most common fly in dwellings, at least in temperate North America. For example, over 88,000 of a total of 96,000 captured in a western city proved to be this species.

Disease Carriers

House flies are active agents in the dissemination of typhoid fever, other diseases of the digestive tract, such as cholera, summer diarrhea of children, and are known carriers of the germs of tuberculosis, anthrax, plague, trachoma, septicemia, erysipelas and yaws. There is evidence implicating the house fly as a carrier of trypanosomiasis and probably of ophthalmia in Egypt. It has also been definitely associated in recent years with a number of cases of intestinal myiasis.

The feeding habits of flies are admirably adapted to the spread of disease. It is well known that moist materials, such as various foods or pathogenic discharges from the human system, are attractive to these insects and there is abundant evidence to show that flies quickly pass from one to the other. The fluids are sucked up into the crop and at times may be regurgitated. The crop contents of a fly may thus literally swarm with disease germs, especially in insanitary areas, and investigators have demonstrated that certain disease germs may pass through the digestive tract of the fly in a viable condition. This means that disgorged material from the crop, the normal dejecta of the fly, and any particles from the hairy legs or bodies, may convey serious if not deadly infections.

For example, the typhoid outbreaks in army camps during the Spanish War were due in very large measure to flies carrying disease from latrines to mess tables. It is particularly dangerous under such conditions to eat cold food of any kind. This was shown in a typhoid outbreak occurring in the Minnesota iron range where there were abundant opportunities for fly infection. The Finns and Swedes, though far more cleanly in habits and environments than the Austrians and Italians, were chief sufferers, due to the

fact, it is believed, that the former lunched frequently during the day upon cold food which was freely accessible to insects, while the Italians and Austrians had hot meals and used but little milk.

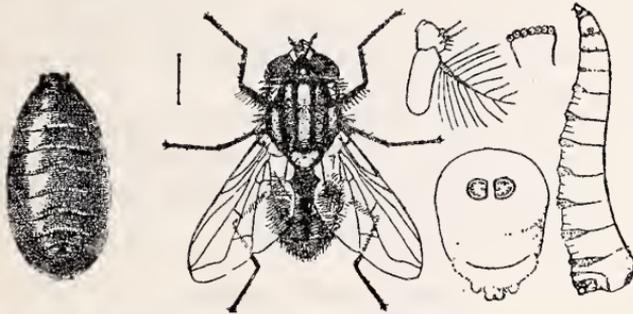


Figure 2 Common house fly, *Musca domestica*, the maggot at the right, the puparium at the extreme left, the lower figure to the left of the maggot is the posterior extremity, much enlarged. (After Howard)



Figure 1 White-faced hornet, *Vespa maculata*, one of our common hornets, enlarged. (After Riley)

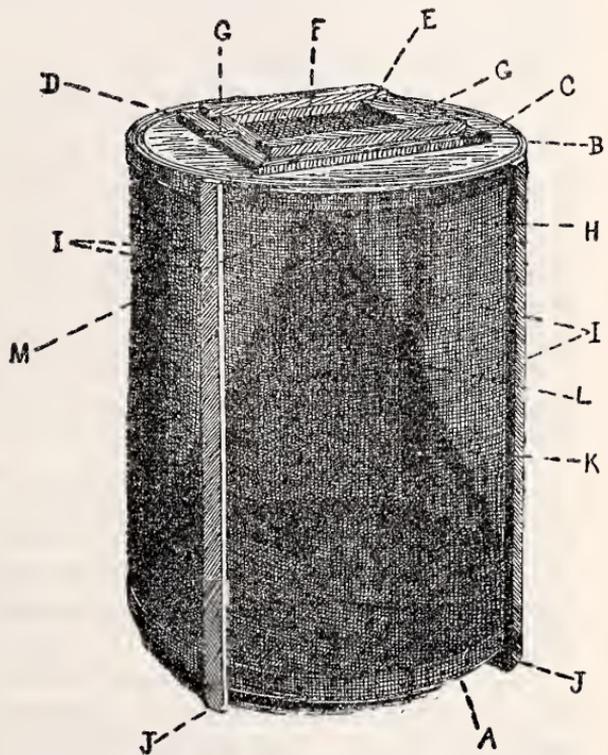


Figure 3 Conical hoop fly trap, side view. A, Hoops forming frame at bottom. B, Hoops forming frame at top. C, Top of trap made of barrel head. D, Strips around door. E, Door frame. F, Screen on door. G, Buttons holding door. H, Screen on outside of trap. I, Strips on side of trap between hoops. J, Tips of these strips projecting to form legs. K, Cone. L, United edges of screen forming cone. M, Aperture at apex of cone. (After Bishopp)

The possibilities of infection can hardly be overestimated when it is recalled that typhoid germs may be discharged from the human system several weeks before diagnosis is possible, continue in numbers six to eight weeks after apparent recovery, and in special cases may persist through a period of years, although the individual is apparently in excellent health. Even the urine from such persons may contain living typhoid bacilli.

It should be noted that the house fly is a mechanical carrier and the statements in respect to typhoid fever apply with equal, if not greater force to cholera and to a more limited extent to the other infections named, especially tuberculosis.

Prevention of Disease

The first essential, in view of the above, is to prevent the spread of disease by the prompt disinfection of all discharges, both fluid and solid, from typhoid fever and other patients, thus making fly infection impossible so far as individual cases are concerned.

The greatest care should be taken to exclude flies from the sick room or hospital, especially where there are contagious diseases. The pests not only annoy the patients but may carry the disease to others. Accumulations of exposed fecal matter in the vicinity of human dwellings or camps should not be tolerated, since disease can be easily contracted from such sources. Deposits of human excreta in the open are equally dangerous and there is a similar menace along the shores and about wharves with inadequate sanitary provisions. This is also true of the frequently exposed sewer mouths.

There is no greater menace to health in the country districts and many villages than the privies as they exist at present. A satisfactory structure should be water tight, so as to prevent possible contamination of water supplies, vertebrate proof in order to exclude all small animals especially rats, and fly proof since these materials not only infect flies but frequently provide suitable breeding places. The great probability of privy contents being pathogenic makes it very desirable that the accumulations should not be exposed when they are cleaned out or removed. It is entirely possible to meet all of these requirements at a reasonable expense, although not without the expenditure of some time and the constant exercise of care in respect to details. The dangers attending the ordinary privy are shown by a survey of 201 in the South, which demonstrates practically a 5 per cent infection with germs of amoebic dysentery, the cysts of which apparently remain viable in the flies' intestines for 49 hours and are therefore easily carried from such places to foods in nearby kitchens, dining rooms or restaurants.

Habits and Life History

The house fly breeds by preference in horse manure, though it occurs to a limited extent in cow manure, human excrement and miscellaneous collections of organic matter. It winters in the latitude of New York probably mostly as a larva, possibly sometimes in the puparium. The fly, rather frequently found in houses during cold weather and commonly supposed to be the house fly, is in most cases the cluster fly, an entirely different species.

The maggots of the house fly hatch from eggs in less than 24 hours after deposition, complete their growth under favorable conditions in from five to seven days, transform to oval brown puparia and remain in this condition from five to seven days. The life cycle is therefore completed in from 10 to 14 days, the shorter period being true of the warmer part of the year. One fly may deposit 120 eggs and under favorable conditions there may be 10 or 12 generations.

Recent observations show that the maggots or larvae thrive only in substances which are more or less alkaline and that they are unable to develop to maturity in the presence of comparatively small amounts of organic or other acids. They are also sensitive to excessive moisture and are found only in the drier portions of manure heaps. It is stated that this insect breeds in large numbers in stables and refuse stored close to buildings, the open pile located far from houses being but little frequented. It is possible that the state of fermentation is more important than proximity to dwellings or other shelters. The maggots thrive only in certain portions of the manure pile, namely, in a layer some inches deep and lying a few inches below the surface where there is a moderate amount of heat and moisture, an excess of either being fatal or compelling migration. They can exist to only a relatively slight depth in well packed manure.

Control Measures

Generally speaking, fly production is local and the keeping of manure and other fly breeding materials in fly-proof pits or the removal of all such matter at frequent intervals is a most logical way of handling the problem. This appears easy, although under practical conditions it is difficult.

The essential in a manure pit is that it should be fly-proof. It may be under or beside a stable and the trap or door through which the manure is thrown should, if possible, be moderately dark and at the other end or above there should be a fairly light window or fly trap in order to attract insects away from the entrance. This arrangement largely prevents the escape of flies whenever manure is thrown in or carried away.

The removal of manure, preferably at daily intervals in cases where there is a pit or cellar, if thoroughly done, makes local breeding impossible, if it be properly spread, and insures that the contained eggs and young maggots quickly perish from exposure.

Hellebore, one-half pound to ten gallons of water, applied to eight bushels of manure is an effective larvicide and not injurious to plants. Borax used at the rate of two-thirds of a pound to ten gallons of water for the same amount of manure is less expensive and less efficient. It has an injurious effect on plant growth and not more than 15 tons of manure treated in this way should be used to an acre in order to avoid the possibility of injuring crops.

Formaldehyde, a 40 per cent solution diluted with five or six volumes of water or milk, is one of the safest and most effective fly poisons. A little sugar or other sweet may be added to the solution. Put the mixture in shallow dishes in places where flies are numerous. This will be more effective if a little bread is added to serve as an alighting place and water or other fluids attractive to insects are not near at hand.

Fly traps (see fig. 3) of various designs and sticky fly paper are also effective in capturing flies in dwellings. It is much more satisfactory, however, to prevent their entrance by eliminating nearby breeding places or by the judicious use of screens for doors and windows.

OTHER FLIES

There are a number of other flies which occur in small numbers in houses or are found about dwellings and are therefore of interest, even though in some cases disease carrying has not been proved.

The little house fly, *Homalomyia canicularis* Linn., (see fig. 4) appearing as an undersized or young house fly, occurs rather commonly upon windows in houses. The maggots, easily recognized by the series of somewhat spiny processes, are found in decaying and fermenting organic matter, including excrement. A closely related species, *F. scalaris* Fab., is called the latrine fly on account of its commonly breeding in human excrement. Both are undesirable if not dangerous inhabitants of dwellings, and are rather common causes of intestinal myiasis.

The cluster fly, *Pollenia rudis* Fab., is the one rather commonly found in dwellings during the winter and early spring and frequently mistaken for the house fly. It is somewhat larger, darker and with the thorax usually covered rather thickly with tawny hairs which incline to a grayish shade. The maggot is para-

sitic in certain earth worms and the adults are notorious because they invade houses in large numbers in early fall. This insect is also known as the buckwheat fly.

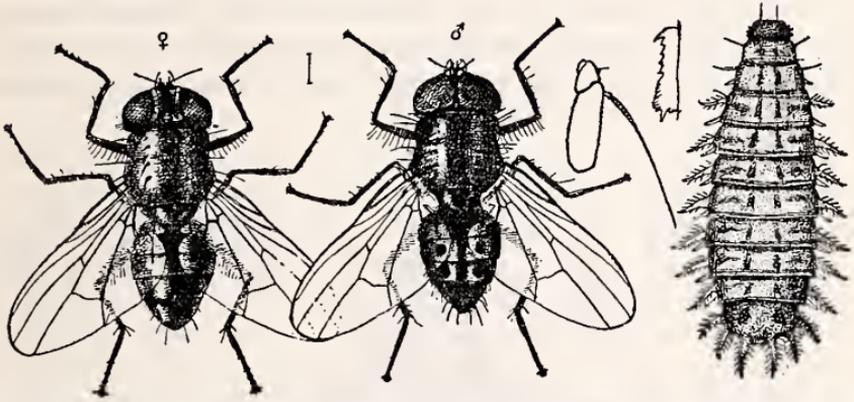


Figure 4 A little house fly, *Homalomyia brevis*; female at the left, male in the center and larva at the extreme right. (After Howard)

The biting house fly, *Stomoxys calcitrans* Linn. (see fig. 5), resembles the house fly very closely indeed and is most easily distinguished by the moderately sharp, pointed mouth parts, markedly different from the stout, lobed proboscis of the house fly. It is more an outdoor stable fly than a house fly. The maggots are found in decaying wheat, straw or straw and manure. The life cycle is completed in about five to six weeks. This insect is a potential carrier of anthrax, it has been under suspicion as a carrier of infantile paralysis and it or a closely allied insect is credited with disseminating surra.

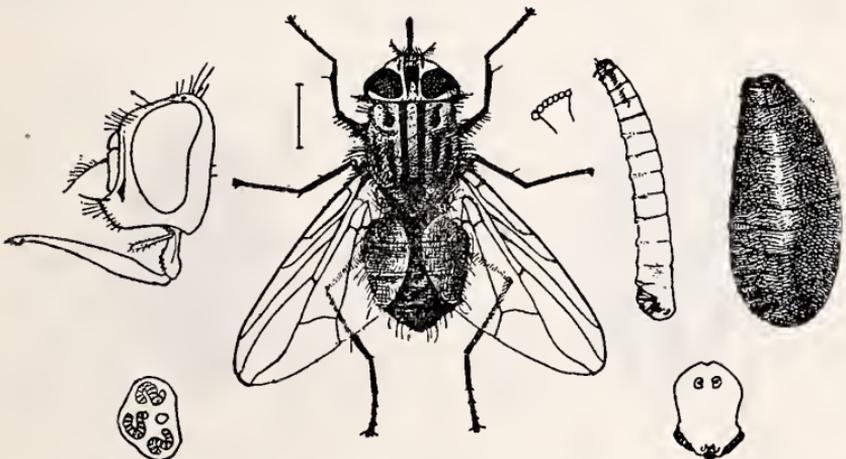


Figure 5 The stable fly or biting house fly, *Stomoxys calcitrans*, to the right the puparium, the larva and its posterior extremity greatly enlarged, to the left a side view of the head and one spiracle much more enlarged. (After Howard)

The stable fly, *Muscina stabulans* Fall. (see fig. 6), is very similar to the house fly, somewhat larger and is usually found in houses in early summer about the same time as the small house fly. The eggs are laid and the larvae occur in various kinds of decaying or decomposing organic matter and have been recorded as predacious upon house fly maggots. There are several records of this species causing intestinal myiasis.

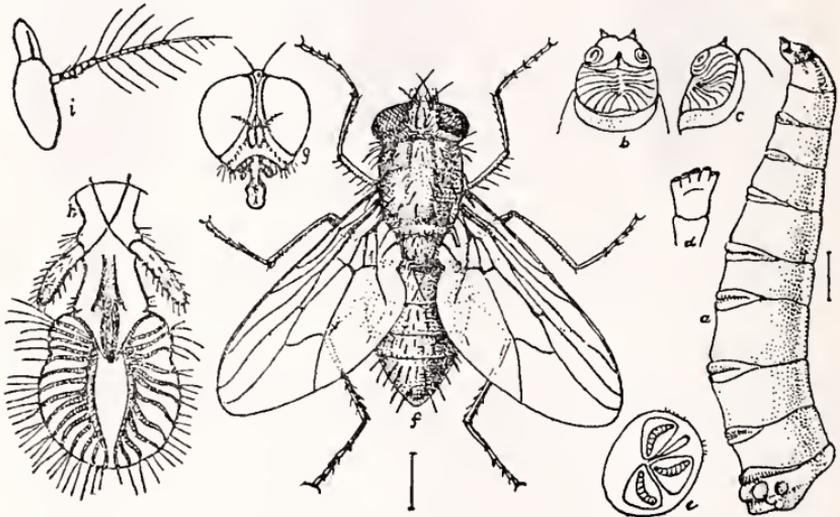


Figure 6 A stable fly, *Muscina stabulans*, adult and details of structure to the left, larva and structural details to the right. (After Howard)

Blowflies and bottle flies are the larger buzzing flies sometimes invading houses and more commonly abundant about carrion, slaughter houses, rendering plants, and the like (see fig. 7).

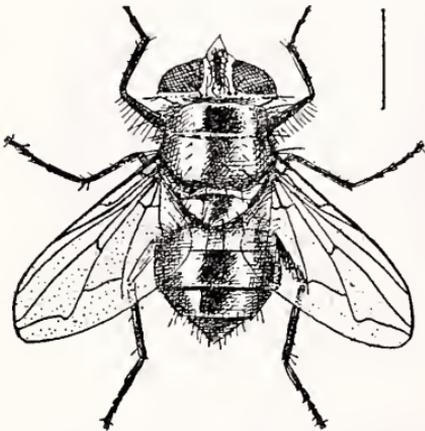


Figure 7 A bluebottle fly, *Phormia terraenovae*. (After Howard)

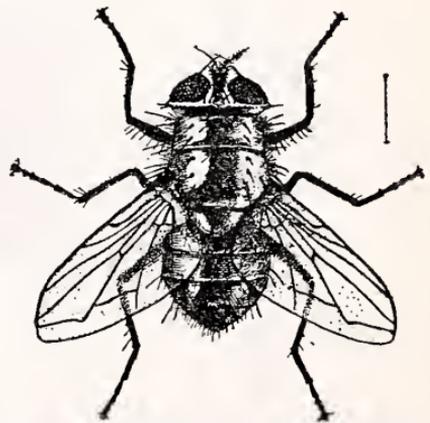


Figure 8 A green-bottle fly, *Lucilia caesar*, much enlarged. (After Howard)

The queen blowfly, *Phormia regina* Meign., is the common black fly, markedly larger than the house fly and so frequently seen in early spring in houses. It is one of the more abundant species about slaughter houses. The life cycle is completed in from 10 to 25 days. This fly is responsible for most of the "wool maggots" of the Southwest and its larvae are also found in old festering sores on cattle.

The large bluebottle fly, *Cynomyia cadaverina* Desv., an associate of *Phormia*, frequents pantries and cellars and oviposits on food products of animal origin, such as smoked, uncured and cooked meat. The life cycle may vary from 13 to 99 days.

The blowfly, *Calliphora erythrocephala* Meign., has a marked preference for carrion and may complete its life cycle in from 15 to 20 days. Parker (1922, p. 127) describes a series of experiments which are suggestive of pedogenetic reproduction in the autumn by this species.

The green-bottle fly, *Lucilia caesar* Linn. (see fig. 8), is another of these flies developing from puparia on the first warm days of spring. The life cycle may be completed in from 11 to 24 days. There is a closely allied species, *Lucilia sericata* Meign., with very similar habits.

The "screw worm" fly, *Cochliomyia macellaria* Fab., a southern insect, winters as larvae, the flies appearing shortly after warm weather. This species breeds in animals which have recently died, and has caused numerous losses among cattle and other domestic animals owing to its habit of depositing eggs in recent flesh wounds. The maggots aggravate the injury, and unless quickly discovered, may produce serious results. This fly also attacks man, depositing eggs in the nostrils or mouth while the victim is asleep. Such attacks are usually limited to sufferers from catarrh. The maggots work rapidly, and unless speedily discovered and destroyed, the tissues of the nose, mouth and soft palate may be honeycombed and the victim lose his life. From 40 to 248 eggs may be deposited in one batch and a female may lay 1228. The life cycle may be completed within about 2 to 7 weeks.

Another flesh fly, *Wohlfartia vigil* Walk., fortunately not common, has been recorded as attacking man, mostly infants, and producing on the arms, neck and chest, exposed portions of the body, boil-like, red, pustular sores half an inch or so in diameter. Each sore has a minute and very inconspicuous opening and contains one or more maggots. Recently one of these flies deposited several eggs in the eye of a stone-cutter in this State, the sensation being much as though a piece of marble had flown into the eye, and on

examination the next day a small cyst was observed and from it several maggots of this species were removed. The related European *W. magnifica* Shiner has been rather commonly associated with maggot infestation of the eye, nose and ear, the loss of sight, hearing, and in very extreme cases, death has resulted.

These blowflies, bottle flies or flesh flies as they are variously called breed in a considerable variety of animal matter and their presence in any numbers is presumptive evidence of a moderately near breeding place. Burying carcasses to a depth of at least two feet is advised. A few inches of soil packed well over a carcass will prevent infestation, although not the emergence of flies. A number of blowflies produce myiasis. See the following account of myiasis and fly maggots.

Dried egg (whole or egg yolk) when moistened and kept alkaline makes a very attractive bait for flies (Bishopp *et al* 1923, p. 224).

Other flesh flies belonging to the genus *Sarcophaga* have been definitely associated with intestinal myiasis. The European *S. haemorrhoidalis* Fall., appears to be able to develop to full size within the intestines, although such is not the case with the maggots of *S. carnaria* Linn., the former widely distributed in America. Symptoms associated with such an infestation are recorded as follows in the case of a child some 20 months old: The patient had been sick for 45 days and for the first three weeks the temperature had run from 103 to 106°, though there was a continued application of an ice pack to the head. During the second week the child developed true meningeal symptoms, these continuing for about five days. There was no pain, although there was some abdominal distension which was easily relieved by enema or tube. At no time was there any definite train of symptoms permitting a diagnosis. In November it was stated that the child had a temperature of 102° F. and was taking a normal amount of nourishment, but was very sick. After the use of calomel one dipterous larva, identified as that of the bluebottle fly, was passed in the feces. Whether there was more than one maggot in the intestines was not known. It is possible the infestation developed through the child gaining access to fly-blown meat.

The rat-tailed maggots of the drone fly, *Eristalis*, have been recovered from the human alimentary canal, in one case producing an illness of 10 weeks' duration. The consumption of cheese infested by maggots of the cheese fly, *Piophilacasei* Linn., has been followed by severe indisposition, extending over several days and accompanied by vertigo, severe headaches and eventually pain through the entire alimentary canal.

Fruit flies, *Drosophila melanogaster* Meign. (see fig. 9), and *D. a moena* Loew, are easily recognized as the light brown pomace flies, only about one-eighth of an inch long, so commonly found about cider mills and overripe or partly decaying fruit. They are attracted by such materials and may frequently be observed upon jars containing preserved fruit. Their small size makes it very difficult to keep them out of houses. They are possibly disease carriers in a very limited way.

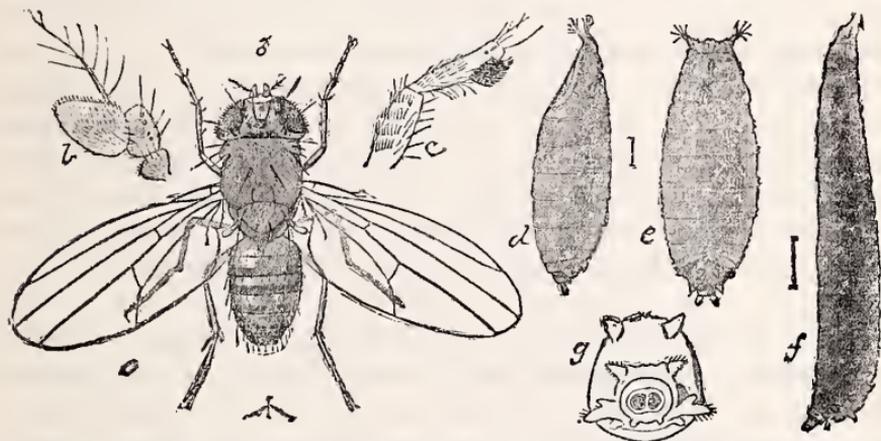


Figure 9 Fruit fly, *Drosophila melanogaster*: A, adult; B, antenna; C, base of tibia and first tarsal joint; D, puparium, side view; E, same dorsal view; F, larva; G, anal segment of same; A, D, E, F, much enlarged; B, C, G, still more enlarged. (After Howard)

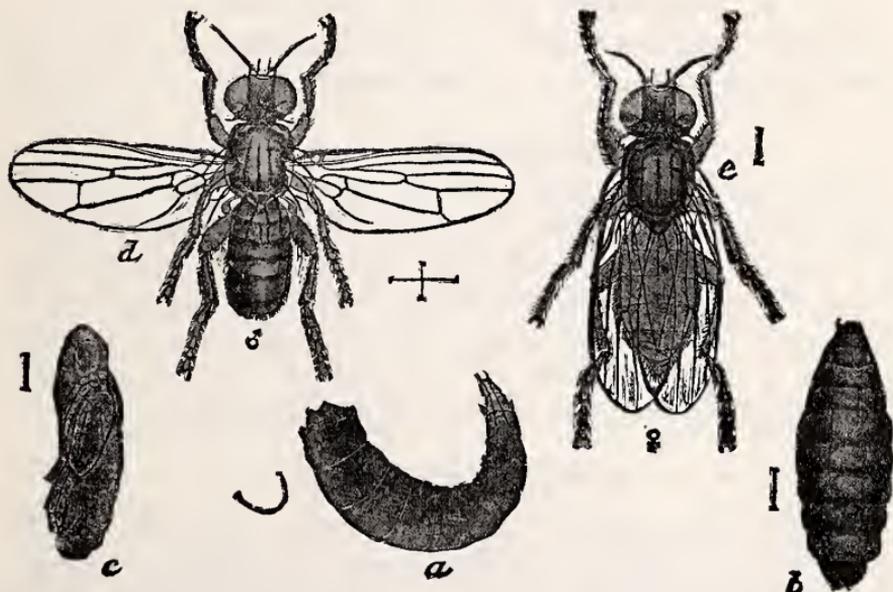


Figure 10 Cheese skipper, *Piophilha casei*: A, maggot or larva; B, puparium; C, pupa; D, male fly; E, female; all enlarged. (After Howard)

The small black flies of the cheese skipper, *Piophilacasei* Linn. (see fig. 10), occur about houses in association with cheese, ham, etc. It is hardly a dangerous species.

Horse flies or deer flies, Tabanidae, are moderate to large-sized flies and are represented by considerable series of species. They are common in the vicinity of wet or marshy areas, the carnivorous maggots developing in moist organic matter. A number of these flies are persistent biters and certain species are known to carry surra from diseased to healthy animals. There is also evidence of their transferring anthrax and even a species of filaria.

The extremely minute punkies or "no-see-ums," most easily recognized by the fiery, stinging, apparently causeless bite, are midges belonging to the genus *Culicoides*, family Ceratopogoninae, and well known as veritable pests in the Adirondacks. The slender maggots are found in ponds, pools and similar places. These insects have not been associated with the dissemination of any disease.

The small moth fly or Psychodid belonging to the genus *Phlebotomus* is best known because the European *P. papatasi* Scop., transmits the European "papataci fever" or "three-day fever." There is somewhat conclusive evidence to show that a South American species carries the virus of the Peruvian "verruca." There are six American species concerning which little is known.

MYIASIS AND FLY MAGGOTS

Ordinarily maggot infestation of the human body is more or less casual, though there are some marked exceptions.

Blood Sucking Maggots

The Congo floor maggot, *Aucheromyia luteola* Fabr., occurs throughout tropical Africa, the dirty, white maggots sheltering in crevices in the floors of native dwellings and issuing at night to suck the blood of sleepers. This is a distinctly unusual type of attack so far as man is concerned. It is interesting to note that the larvae of the Californian *Protocalliphora azurea* Fall., is nest-inhabiting and sucks the blood of young swallows.

Dermal or Skin Maggots

The South American skin maggot, *Dermatobia hominis* Gmel., occurs throughout tropical America and its larvae develop not only in man but also in animals, such as dogs, cattle, mules, hogs. In certain parts of South America the hides of cattle are

fairly riddled with holes and worthless on account of infestation by this pest. The swellings produced by this maggot in man are very painful at intervals, coincident probably with times of maximum activity. The grubs mature in boil-like swellings and cause exudations of pus. The wounds heal quickly after the larvae are ejected or escape. It has been established that this fly captures mosquitoes, house and other flies, deposits a number of eggs upon the victims and then allows them to escape. The larvae do not emerge until the eggs are near the warm skin of human and other hosts. This remarkable habit has been established by several observations, although it may not be the only manner in which man and animals become infested.

The larvae of the African tumbu fly, *Cordylobia anthropophaga* Grünb., is the commonest maggot developing under the human skin in Africa, although man is not the main host, a number of wild and domestic animals, especially dogs, being subject to infestation. As many as 300 maggots have been taken from the skin of a puppy and it is not unusual for 20 or more to be found in a man. They produce boil-like sores very much like those described above. Puppies and infants are especially liable to attack. The wild rat is considered the natural host by Blacklock and Thompson.

The common warble flies of cattle in the United States, *Hypoderma lineata* DeVil. and *H. bovis* DeG., occasionally attack human beings in this country, though this is far from common. Cutaneous myiasis is also recorded for the house fly (Patton and Cookson 1925, p. 1201).

Hypodermal myiasis, using the term in a broad sense, is not limited to insects. Recent investigations (Kirby-Smith, Dove and White, 1926, p. 137) of the somewhat prevalent creeping eruption of the Southeastern States in particular have shown that the damp sand type is due to infestation by the microscopic third instar of a small roundworm or nematode, described as *Agamonematomum migrans* Kirby-Smith, Dove and White. Infestation is characterized by linear, tortuous and serpiginous eruptions caused by the movement of this parasite within the skin and accompanied by intense itching. The most recent visible lesion is a very narrow erythematous formation soon followed by a slightly raised line indicating the location of the burrow. The parasite apparently remains for a time at the point of entry and produces a reddish sensitive papule not unlike that of the bites of "chiggers," "red bugs" or "harvest mites" and from these points various threadlike burrows may be observed within from two

to four days. The raised portion of the skin over the burrow has the appearance of that made by a mole in meadows. The migration may continue for several weeks and possibly months. Penetration by the parasite is comparable to the bite of mosquitoes or ants or contact with needles, followed by itching which sometimes becomes so intense as to be almost unbearable. Loss of sleep and appetite occur and in extreme cases loss of weight and vitality. This occurs chiefly in the South Atlantic and Gulf States and has been associated with dogs and cats (White and Dove, 1926 p. 6).

Maggots in Wounds and Body Cavities

Infestation of wounds and of natural cavities of the body is rather common in the South by larvae of the screw worm fly, *Cochliomyia macellaria* Fabr., the flies being attracted particularly to wounds and to individuals suffering from foul-smelling catarrh. The maggots develop very rapidly and there are records of the penetration by this species of the pharynx, frontal sinus, the eyeball and even the brain, the more severe cases resulting in death. An abundant discharge of pus and scraps of tissue, intense pain and even delirium may accompany the infestation.

The related green-bottle fly, *Lucilia caesar* Linn. and the common blowflies, *Calliphora vomitoria* Linn. and *C. erythrocephala* Meign., also breed in wounds, although they are much less dangerous than the screw worm. Maggots of the sheep bot-fly, *Oestrus ovis* Linn., have also been associated with attacks on man.

Flesh flies occasionally attack man. There have been several cases in this county (see the account of *Wohlfartia vigil* Walk., p. 19).

Ticho observed in Britain six cases of external ophthalmomyiasis during a period of ten years by *Oestrus*-like larvae, *Oestrus ovis* Linn., the common sheep bot and *Rhinoestrus pupureus* Brauer respectively. There was a similar antecedent history (Ticho, 1923, p. 177). See also Herms, (1925, p. 54).

Another flesh fly, *Sarcophaga carnaria* Linn., occasionally deposits its eggs on living animals and is especially attracted to discharges from the nose, ears and other body cavities.

Maggots in the Digestive Tract

Intestinal myiasis is largely casual and usually results from the ingestion of decayed fruits and vegetables, fresh or cooked meats or even cold foods to which flies have access. The maggots of a

number of these species, namely those of the house fly, *Musca domestica* Linn., the lesser house fly, *Fannia canicularis* Linn., the latrine fly, *F. scalaris* Fabr., rat-tailed maggots, (Hall, 1920, p. 65) *Eristalis* and *Helophilus*, the cheese skippers, *Piophilacasei* Linn., and several species of flesh flies, *Sarcophaga*, have been associated with this condition. Larvae of the stable fly, *Muscina stabulans* Fall., have this habit in Korea. Even millipeds, *Julus* sp., have been recovered from the alimentary tract.

The effects are quite variable and in some cases the maggots may be passed without marked inconvenience. In others there may be rather serious temporary intestinal disturbances, such as loss of appetite, vomiting, abdominal pains, diarrhea, constipation, intestinal bleeding and sometimes headache and vertigo, the last two indicating the absorption of toxic substances secreted by the maggots. Cases of death from such infestations have been recorded. The more serious symptoms usually result from the maggots attacking the linings of the stomach and intestines. Even those of the house fly have been associated with such injury. There is a record of a case in the Philippines, where the walls of the stomach were extensively eaten away, some 20 or 30 house fly maggots being obtained.

Human myiasis, as might be expected, appears to be much more common in tropical and subtropical regions.

It is evident from the above that intestinal myiasis can be prevented almost entirely by exercising reasonable care in the selection of foods and avoiding those likely to contain either eggs or larvae. Usually fly maggots can be expelled readily by purging with drugs used for intestinal worms.

A somewhat exhaustive account of myiasis producing Diptera is given by Major Patten (1921, p. 239.)

BLACK FLIES

Black flies or buffalo gnats, *Simulium* spp., are small, stout, black insects about one-tenth of an inch long, some with white banded legs, which are most easily recognized, in the case of certain bloodthirsty species, such as the buffalo gnat, by their settling upon man and animals in large numbers and drawing blood. These insects are especially likely to establish themselves in rows behind the ears or along the hatband, if a hat is worn. They are particularly abundant in the wooded areas of the Adirondacks, in portions of Minnesota, and in some of the Southern States, especially from Tennessee south. They are very likely to be injurious after floods

and in Mississippi and other southern states have caused the death of cattle, horses and mules, and in more than one instance have actually imperiled human life. There seems to be a definite toxic action. In severe attacks, animals at first behave as though suffering from colic and in two or three hours the heart is affected. They pass into a stupor and soon fall dead. (Barnett, 1927, p. 50)

The investigations of Doctor Stokes (1914, p. 751) have shown that in spite of the painless bites of these insects, there is a somewhat definite development which may extend over a period as long as three weeks. There is first the papular stage, which appears in 3 to 24 hours, next an early vesicular or pseudovesicular stage requiring 24 to 48 hours for development, and then a mature vesicopapular or weeping-papular state follows by the third day and may last from a few days to three weeks. Pruritis develops with the pseudovesicular stage, and owing to the usual grouping of the fly bites and the confluence of the lesions, there may be an extensive oedema with a formation of oozing and crusting plaques. The final state of involution is marked cessation of oozing, subsidence of the papule and scarlike changes on the site of the lesion. There is a distinctive satellite adenopathy of the cervical glands in most susceptible persons.

There have been unsuccessful attempts to prove a connection between these insects and the occurrence of pellagra. *Simulium* is suspected of being a disease carrier in Africa (Dry 1921, p. 233).

The greenish or dark colored gelatinous larvae occur mostly on rocks in comparatively shallow water, frequently forming almost continuous patches over areas of several square feet. Experiments in recent years have demonstrated the practicability of destroying these larvae in streams by applying an oil preparation, such as phinotas. This is heavier than water, settles to the bottom, and a film of oil may be found upon stones 48 hours after application. Black fly larvae may be killed an eighth of a mile below the point of application. Unfortunately fish may also be destroyed unless this compound is used in small quantities. Floods are favorable to black fly development. Consequently judicious stream regulation has an important effect in reducing the numbers of these pests.

MOSQUITOES

Mosquitoes are of primary interest in New York State because certain species are active carriers of malaria, while in warmer climates one has been definitely associated with the dissemination of the greatly dreaded yellow fever, and others carry the organism

responsible for filariasis. In passing, there are some 60 different species of mosquitoes in the State, mostly with well-defined habits and breeding places, and in a few cases with a very remarkable limitation, as for example in the small, innocuous form which lives only in the water found in pitcher plants.

The malarial mosquitoes, *Anopheles*, the carriers of malaria, are easily recognized by the spotted wings (see fig. 11) and especially by the characteristic resting position (see fig. 12), the beak and body being in almost a straight line and at a considerable angle to the supporting surface. The larvae or wrigglers have no conspicuous air tube and remain in a characteristic, nearly horizontal resting position just beneath the surface film (see fig. 14). They are usually rather strongly marked with bright or dark brown and green and occur commonly in springs or water holes, in stream beds, occasionally along the edges of running streams, and not infrequently in grassy pools. The adult mosquitoes are rarely numerous, fly at twilight and winter in dwellings and other shelters. Occasionally they are rather abundant in houses. The most common species in New York State is *Anopheles punctipennis* Say, a strongly marked form, while *A. maculipennis* Meign. is less abundant and the more common malarial carrier.

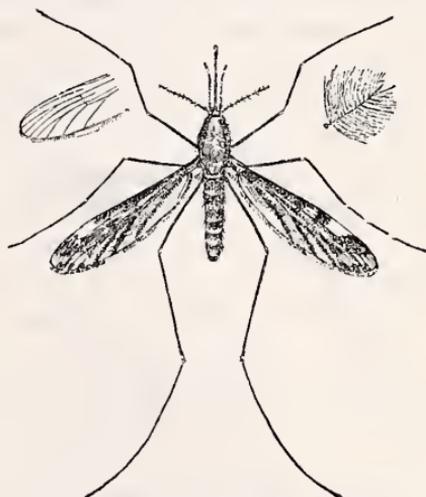


Figure 11 Malarial mosquito, *Anopheles punctipennis*, female, with male antenna at right and wing tip showing venation at left. (After Howard)

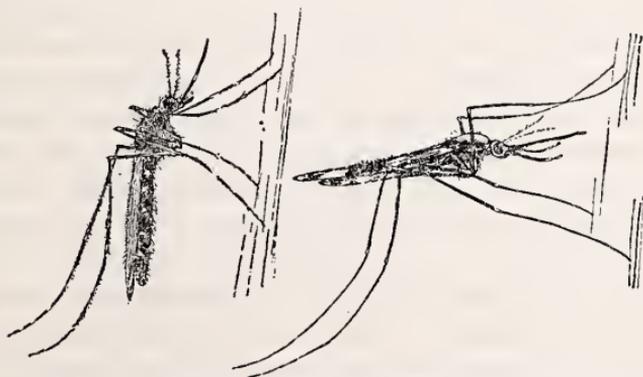


Figure 12 Common and malarial mosquitoes at rest, the latter to the right. (After Howard)

The narrowly oval, blackish eggs of *Anopheles* are laid in small numbers upon the surface of the water, lie upon their sides and float by means of lateral expansions. They hatch in from two to four days, much presumably depending upon prevailing temperatures. The larvae establish themselves just under the surface film and feed to a considerable extent at least upon green algae and other small particles in the water. Full growth requires some two weeks; the pupal stage occupies

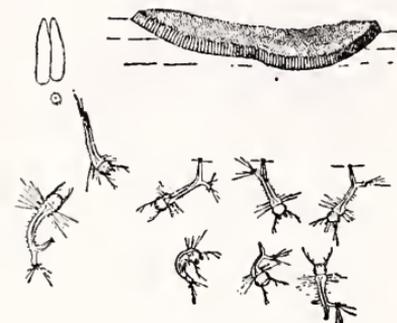
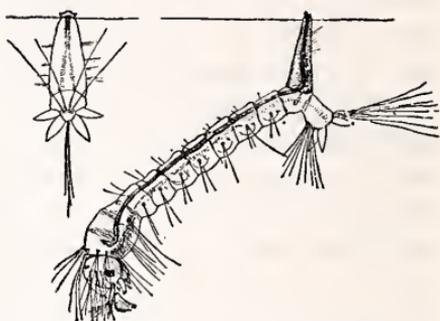
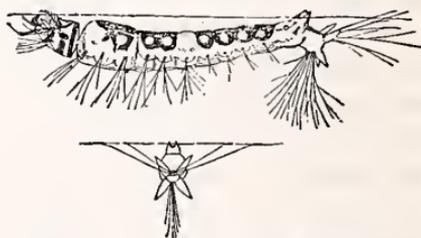


Figure 13 House mosquito, *Culex pipiens*: Egg mass with enlarged eggs above and at the left; young wrigglers below. ;(After Howard)

Figure 14 Characteristic feeding position of malarial mosquito wriggler in upper figure, and that of the common rain barrel or house, mosquito in lower figure. (After Howard)

about five days, the life cycle being completed in about 24 days. Breeding may occur through most of the season.

The malarial mosquitoes, unlike the house fly, are alternate hosts for the diseases they convey. That is, the malarial mosquito, before it is capable of conveying an infection, must first bite someone already suffering from malaria, even though this be only a latent type, and then after a period of 10 to 12 days, during which time the malarial parasite undergoes definite changes within the body of the mosquito, the insect is then in a position to convey the infection, since at that time the malarial germs are present in the saliva and are injected into the blood stream as the mosquito bites. This explains how malarial outbreaks may follow the appearance of Italians or others with a latent infection in a neighborhood inhabited by non-immunes. The *Anopheles* simply carry it from one to the other.

The control of malaria, it will be seen, depends either upon safeguarding against infection or the prevention of mosquito breeding, and in most cases it is really a combination of the two.

Before discussing control measures it may be well to notice briefly a few other mosquitoes, either on account of their common prevalence or because of the part they play in disseminating disease.

The house or rain-barrel mosquito, *Culex pipiens* Linn., is a modestly colored, brown mosquito which is frequently troublesome about dwellings and, like the malarial mosquito, winters in cellars or other retreats, although it is much more rare in heated dwellings. The long-tubed larvae or wrigglers of this mosquito are found almost exclusively in artificial collections of water, especially tubs, rain-barrels, eave troughs, etc. The moderately stout air tube, with a length about 5 times its diameter, of this wriggler supports the larva as it hangs at a considerable angle from the surface film. The egg clusters of this species are black, raftlike objects, which float upon the water and have a major diameter of less than one-fourth of an inch (see fig. 13). Breeding commences with the approach of warm weather and may continue under favorable conditions till checked by frosts in the fall. The life cycle may be completed in ten days.

The mosquito very closely related to the preceding and known as *Culex fatigans* Wied. has been definitely associated with dengue or "breakbone" fever (in Australia the carrier is *Aedes calopus* Meign.), a disease probably most frequently met with in the West Indies, but which may occur in any tropical country or island, often as a wide spread epidemic. Occasionally it is found in subtropical or even temperate regions, and once introduced spreads very rapidly. This mosquito and several others are hosts of *Filaria nocturna*, the cause of filariasis or elephantiasis.

The yellow fever mosquito, *Aedes calopus* Meign., is a medium-sized, dark brown species with a strongly contrasting, silvery white lyre-shaped mark upon the thorax. It is widely distributed in the Southern States and may occasionally establish itself farther north during the summer. It is frequently known as the "day mosquito" on account of its flying freely in the daytime. This insect has in the South much the same habits as our northern house or rain-barrel mosquito. It breeds by preference in the water of cisterns, tanks and other places and appears to be unable to sustain itself in the open. The larvae or wrigglers are peculiar in that they hang nearly perpendicularly from the surface film. Like the malarial mosquito, the yellow fever mosquito must be infected for a certain period, some 12 days, before it is capable of transmitting the infection, and can become infected only during the first three or four days after the patient comes down with the disease.

The salt marsh mosquito, *Aedes sollicitans* Walk. (see fig. 15), is typical of several species which breed by preference in brackish water. This mosquito is easily recognized by its moderately large size, the broadly white-banded legs, beak and body, the last in addition bearing a conspicuous longitudinal white stripe. The salt marsh mosquito and its allies, unlike the malarial and house mosquitoes, winter as eggs. The latter are deposited upon the mud of salt marshes, the hatching occurring with the flooding at high tides, only a portion at each high tide. Consequently there is a somewhat irregular series of approximately monthly broods developing in the salt marshes and frequently drifting with favorable winds to considerable distances, even so far as 40 miles. The salt marsh mosquitoes breed in such numbers and are so voracious that during recent years there has been very general drainage of marshes in the vicinity of the larger cities and a great reduction, and in some cases a practical elimination of the pests.

Other native mosquitoes occasionally become troublesome, although as a rule they do not travel far from their breeding places. The irritating mosquito, *Mansonia perturbans* Walk., deserves special mention, since it is one of the fiercest and hardest biters and enters houses readily. It is easily recognized by its large size and the strongly contrasting colors, especially the pearl-white band near the middle of the beak and the similar bands on the legs, the broad ones upon the posterior tibiae being characteristic. The segments of the abdomen are white-banded distally and the wings with their large white and dark scales, have a somewhat peculiar mottled appearance. This species is remarkable among native forms in that the wrigglers or larvae attach themselves by the strongly tapered and pointed air tube to the submerged roots of cat-tails, water loosestrife and possibly other plants. This peculiar habit restricts breeding to permanent swamps, particularly cat-tail areas, having more or less floating or semifloating vegetation and renders oil applications of little value as a method of control for this species.

Mosquito Control

Mosquitoes can not exist without water, although under certain conditions the adults may drift with the wind for considerable distances. The larvae or wrigglers of all the more abundant species, excepting those of the irritating mosquito, must come to the surface frequently for air.

It is self-evident that the disease carriers, the malaria mosquito and the yellow fever mosquito, for example, are of primary import-

ance wherever there is an opportunity for these insects to become infected and thus in turn be able to act as carriers of these diseases. Keeping such mosquitoes from infection renders them harmless so far as spreading disease is concerned and if for any reason this is impracticable, a thorough campaign of destruction is the only safe course to pursue. This is especially true of the yellow fever mosquito.

The flight of insects is of considerable importance in control work and with the exception of the salt marsh mosquito and some other less abundant associates, most mosquitoes breed in the near vicinity of places where they are numerous, although this is by no means invariable since there are records of even the house mosquito drifting or flying well toward a mile from a particular breeding place. Furthermore, some mosquitoes are rather long-lived and may persist for a considerable time after the temporary breeding pools in which the larvae lived have disappeared. It is possible to trace the flight or drifting of mosquitoes, and under certain conditions this is important because of its bearing upon local control work. Staining adults by spraying them with a solution of eosin, fuchsin, gentian-violet, bismark-brown, methylene blue and orange-G., using one gram to 50 is very convenient. Stain in the evening about two hours before the mosquitoes are released, applying just enough so that it will quickly dry and not saturate the insects. The stained individuals are best recovered in buildings by hand and trapped elsewhere. The weather, direction of prevailing winds, topography etc., all have an influence on the movements of insects and should be given due consideration.

Mosquito control, broadly speaking, means the elimination of breeding places and in this undertaking rigid attention to details is necessary. The apparently unimportant and usually overlooked breeding places are those most likely to be troublesome. The small pool is more dangerous than the pond or lake and the isolated collection of water beside a stream is fully as likely to produce troublesome mosquitoes as the permanent pools of a swamp. The mud holes in seldom-used roads, the stagnant water of roadside ditches and even the collections of water in hoofprints of animals or in vacant lots, are very likely to produce numerous mosquitoes. The rain-barrels and wash tubs so frequently used to collect water from roofs and the much smaller quantities found in rejected containers, such as old firkins, tin cans etc. may produce bloodthirsty hordes. Cisterns and basins containing water are also favorable breeding places.

The most effective measures are the drainage or filling of such areas, the elimination of useless water containers and the adequate

care of others. The drained or filled areas are permanently eliminated as breeding places. The use of kerosene or a moderately heavy crude petroleum distillate is a very effective method of destroying mosquito larvae, since with few exceptions they must come to the surface in order to obtain air and the film of oil, if maintained for at least 12 hours, means the destruction of the larvae. Kerosene is effective, although a somewhat heavier oil is advisable if it spreads quickly, evenly and does not evaporate too rapidly. One part kerosene to three parts of crude oil, up to three parts of kerosene and one part of crude oil, may be used, much depending upon the viscosity of the crude oil. The mixture should be slightly thicker than kerosene. Waste oil from crank cases of automobiles is cheap and very satisfactory.

Oil may be applied with a knapsack pump or sprayed upon the water with any similar device. Oil-soaked sawdust may be distributed upon the water or placed in a bag and submerged. The gradual escape of the oil assists greatly in maintaining a constant film. In some localities dripping devices of one kind or another are used. It is even possible to use the less offensive types of oil on cisterns, providing the water for domestic use is drawn from below the surface. Thorough screening, however, renders this unnecessary.

Larvae or wrigglers may be destroyed by the use of phenol combinations, such as have been employed so successfully in the Canal Zone. The formula is as follows: 150 gallons of crude carbolic acid, which must contain not less than 15 per cent phenol, 200 pounds of common rosin finely crushed and sifted and 30 pounds of caustic soda dissolved in 6 gallons of water. Heat the carbolic acid in an iron tank, using a steam coil with 50 pounds pressure to 212° F., dissolve the rosin in the boiling acid and then add the dissolved caustic soda, mixing thoroughly. Only a few minutes is necessary to complete the preparation and the above amounts make about 3½ barrels. This combination mixes readily with water and tends to remain at the edges of the streams, that which passes down killing as it goes.

Paris green has been used very successfully in killing *Anopheles* larvae. It is diluted with road dust, fine sand or other inert material in a proportion of about ten of Paris green to one of dust. It is applied by sowing in the air from the edge of the pond when winds are favorable to carrying the preparation over the water or with an airplane. (King and Bradley, 1926.) Light applications should be made every ten days, not enough being used to injure fishes or endanger animals which may drink the water.

Engineers in charge of public works, railroads etc., should ever keep in mind the fact that public comfort and general efficiency are seriously affected by hordes of mosquitoes, even if they are not malarial carriers, and plan their excavations and fills in such a way as to leave a minimum of breeding places for these insects.

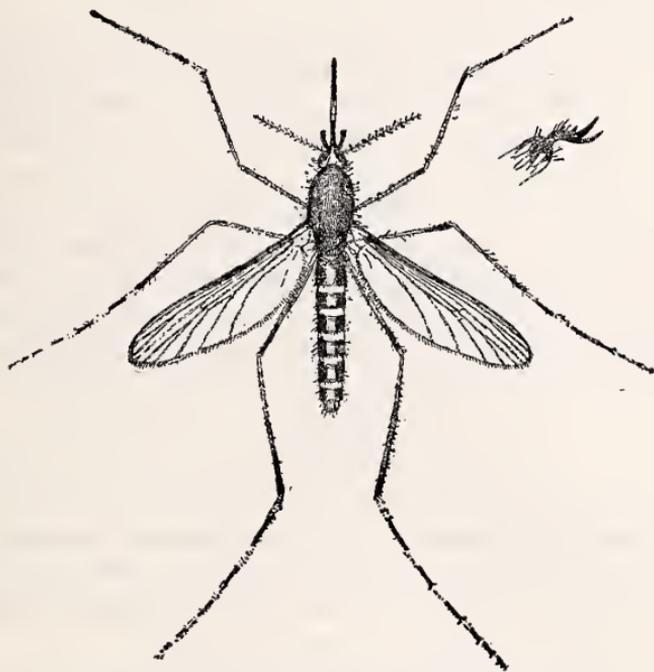


Figure 15 Salt marsh mosquito, *Aedes sollicitans*, from above, the toothed front claw more enlarged. (After Howard)

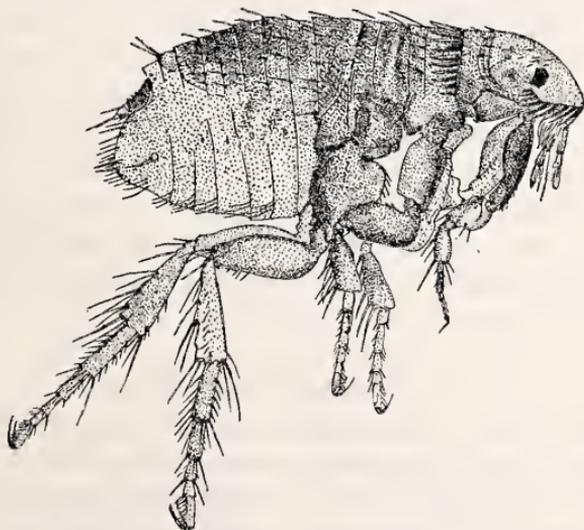


Figure 16 Cat and dog flea, *Ctenocephalus canis*, seen from the side, enlarged

Top feeding fish are very effective checks on mosquito breeding in bodies of water and they should be established in small permanent pools where they do not occur. In the South, carp, pike, mullet, perch, shrimp and small turtles feed upon wrigglers and the smaller of these are recommended for artificial water containers, since their use greatly simplifies control.

Adult mosquitoes may be destroyed in buildings and other inclosures by fumigation with various materials, such as burning moistened pyrethrum, volatilizings Mimms culicide or camphor phenol (3 pounds to 1000 cubic feet), cresyl (5 grams to 40 cubic feet), or cresol (165 cc. to 2640 cubic feet).

Oil of pennyroyal, oil of citronella, oil of peppermint or a mixture of oil of citronella, one ounce of spirits of camphor and .5 of an ounce of oil of cedar, are excellent repellents. Any of these may be combined in the proportions of a few drops to a half ounce of vaseline or lanolin, which will greatly increase their effectiveness, since the grease holds the odor and prevents rapid evaporation.

FLEAS

These active, troublesome insects (see fig. 16) have been definitely associated with the spread of the deadly bubonic plague, a disease which has laid the heaviest tolls upon human life and one of great interest to residents of the United States on account of its having occasionally become established in this country.

Investigations of recent years have established the fact that this plague is a rodent infection, the fleas forsaking dying rats and mice and attacking man. The three plague rats are, the Norway rat, the Alexandrian rat and the Indian black rat. See *The Field Rat in Hawaii and Its Control*, Bul. 17, Hawaiian Sugar Planters Association, p. 1-46, 1925, for a summary account of rats and incidentally plague control. Ground squirrels on the Pacific coast are also susceptible to this disease and potential reservoirs of infection. Investigations have shown that plague bacilli multiply in the stomach of the insect, that infested fleas regurgitate blood through the mouth, that this blood spreads out over the body and that inoculation may result by the bite of the insect and by scratching.

Plague Carriers

It is known that plague is carried by a number of fleas (For a key to the genera of fleas, Siphonaptera see Fox, 1925, p. 120), notably the Indian rat flea (*Xenopsylla cheopis* Roth.), the European rat flea (*Ceratophyllus fasciatus* Bosc.),

(see fig. 17) the human flea (*Pulex irritans* Linn.), (see fig. 18) the European mouse flea (*Leptopsylla musculi* Duges), the dog flea (*Ctenocephalus canis* Curtis), the squirrel fleas (*Hoplopsyllus anomalus* Baker and *Ceratophyllus acutus* Baker), the cat flea (*Ctenocephalus felis* Bouche) and rat fleas (*Ceratophyllus anisus* Roth. and *Pygiopsylla ahalae* Roth.). This is a matter of some importance since the Indian rat flea is abundant in parts of seaport cities of the Pacific and Gulf coasts of the United States, while away from the water front its place as a rat parasite is largely taken by the European rat flea and the mouse flea. A recent study of rat fleas at Providence, R. I., showed that the Indian rat flea comprised 75 per cent, the European rat flea 22 per cent, the European mouse flea 2.5 per cent and the dog flea .5 per cent, in a total of 341 rats examined. The average between July and September was 10.2 fleas to a rat and from October to December, 3.7. Consequently, it is only necessary to introduce an infected rat in any of these localities to make possible an outbreak of this deadly plague, something which may easily result through ordinary trade activities. This is evidenced by the development of a few cases of plague in 1920 at Pensacola, Fla., New Orleans, La., Galveston, Beaumont and Port Arthur, Tex., rat examinations by the Public Health Service disclosing rat epizootic in all but Port Arthur.

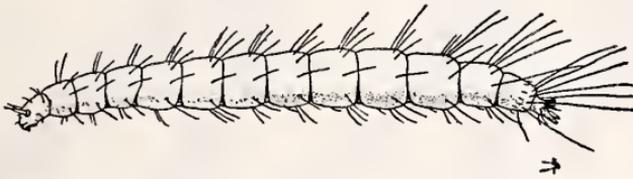


Figure 17 The European rat flea, *Ceratophyllus fasciatus*, larva. Greatly enlarged. (After Bishopp)

A comparative study of rat flea data for several ports on the Atlantic coast, namely, Boston, New York City and New Orleans by Messrs Fox and Sullivan (1925, p. 1909) gives some very suggestive data. In New York City, for example, it was found that 26.8 per cent of the rats trapped on docks or wharves had fleas, 30.9 per cent of those trapped in warehouses adjacent to docks or wharves had fleas, and 49.5 per cent trapped elsewhere in the city had fleas. Similarly, in Boston 30.8 per cent of the rats trapped on wharves or docks carried fleas, 30.9 per cent of those trapped in warehouses adjacent to the water front had fleas, 57.3 of those trapped elsewhere

in the city carried fleas and 25.6 per cent of the rats trapped in the suburbs had fleas. The authors consider it significant that in New Orleans where plague has actually existed, the Indian rat flea, *Xenopsylla cheopis* Roth., is the predominant rat flea present during every month of the year and that the European rat flea, *Ceratophyllus fasciatus* Bosc., is practically absent, while in the northern cities under study where plague has never existed, the European rat flea, *C. fasciatus* Bosc., is

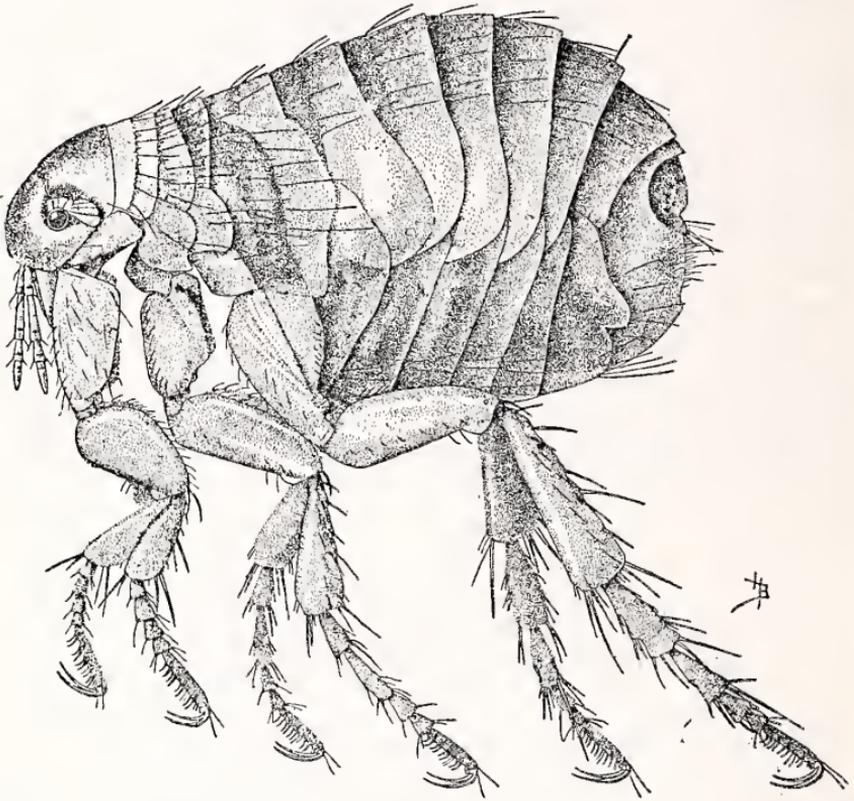


Figure 18 The human flea (*Pulex irritans*): Adult female. Greatly enlarged. (After Bishopp)

the predominant rat flea, while the Indian rat flea, *Xenopsylla cheopis* Roth., appears in greater numbers only during a few months of the year. They also regard it as significant that in New Orleans the average number of fleas per rat is consistently high, as compared with the average number in New York and Boston. They feel that temperature and humidity have an important effect upon the average number of fleas per rat, as well as the numbers of the Indian rat flea, *Xenopsylla cheopis* Roth. These data

are of importance since it is a well-known principle in epidemiology that the mere presence of an insect is not sufficient to produce an epidemic of insect-transmitted disease; the insect must also be present in sufficient numbers. There is therefore a safe minimum which precludes the possibility of an insect-borne disease assuming epidemic proportions. Robertson points out that in modern times plague has not been a real menace north of 35° north latitude, except on the Mediterranean and on the Pacific coast of the United States, because the seasonal prevalence of rat fleas in northern latitudes is too short to permit of a general spread of the plague among rats and from rats to man.

Indian rat fleas are not very active and individuals from plague stricken rats are likely to reach only human beings living in the same house. This species is able to transmit plague 33 days after feeding upon an infected animal. The European rat flea is able to carry plague bacilli for periods of from two to 47 days in the absence of the host. Another significant fact is that British troops in Hongkong provided only with boots, were much bitten by fleas and many contracted plague, while others in India equipped with "putties" did not contract disease because fleas could not get at their ankles. It is evident that flea and rat control eliminates danger from plague.

Habits of Fleas

The more common fleas about dwellings in the Eastern States are the cat and dog fleas, while on the Pacific coast the human flea is the troublesome species. These insects occur upon their hosts, although the human flea appears to pass a portion of the winter upon dogs. There are many species of fleas, most of them closely restricted to certain hosts.

The minute, white eggs of the cat or dog flea are dropped mostly about sleeping places of their hosts, and the slender, active larvae feed upon the organic matter found in the dust. They are particularly likely to thrive in cracks and crevices of floors. The egg stage may last two weeks, the larval period 12 days and the pupal stage from 12 to 16 days, a total for the complete life cycle of five to six weeks.

The human flea develops somewhat more rapidly, the egg stage being given as from four to six days, the larval period 11 days, and the duration of the pupal stage 12 days, making a generation possible in four to six weeks.

The Indian rat flea has an egg period in India of two days and in California of from nine to 13 days, while the usual larval existence

of eight to 24 days, as given by American and English authorities, is extended in California under laboratory conditions to rarely less than 28 and even 30 days and sometimes longer. The adults of this species may live on rats in India for 41 days, the maximum on an exclusive diet of human blood for that locality being 27 days, although in California the insects have been kept alive under such conditions for 36 days. Fleas may live in bran in the absence of liquid food for six days and in sand with moist cow-dung for 13 days.

The following summary from an extensive study by Bacot (1914, p. 447) gives in brief compass some of the possibilities of flea infestation, the possible length of life of the individual being obtained by adding together the maximum periods recorded for every stage.

European rat flea, *Ceratophyllus fasciatus* Bosc., egg 10 days, larva 114 days, cocoon 450 days, adult when fed 106 days, unfed 95 days, possible length of life 680 days.

Indian rat flea, *Xenopsylla cheopis* Roth., egg 10 days, larva 84 days, cocoon 182 days, adult when fed 100 days, unfed 38 days, possible length of life 376 days.

Human flea, *Pulex irritans* Linn., egg 12 days, larva 202 days, cocoon 239 days, adult when fed 513 days, unfed 125 days, possible length of life 966 days.

Dog flea, *Ctenocephalus canis* Curtis, egg 8 days, larva 142 days, cocoon 354 days, adult when fed 234 days, unfed 58 days, possible length of life 738 days.

Bird or chicken flea, *Ceratophyllus gallinae* Schrank, egg 7 days, larvae (estimate) 50 days, cocoon (interrupted by opening) 70 days, adult when fed 354 days, unfed 125 days, possible length of life 481 days. This last species has been recorded from several localities in the United States.

Sandy soil is most suitable for flea development and undisturbed dry dust in buildings and sheds appears particularly favorable. The custom of setting buildings on foundations some distance from the ground, prevalent in the South, thus gives opportunities for cats, dogs and other animals to range beneath, over an unusually dry soil, and affords almost ideal conditions for the development of these pests. This sometimes results in a general infestation of adjacent lawns. Fleas have also been definitely associated with infantile kala-azar and the occasional human infestation, especially of children, by the dog tape worm, *Dipylidium caninum*, the larvae of which develop in both the cat and dog flea and presumably gain access to the human body through close association with cats and dogs.

Flea Control

Domestic animals allowed in houses should be provided with a sleeping mat or blanket and the latter taken up frequently, shaken, and the collected dust burned. Infested animals may have a quantity of pyrethrum powder rubbed into the hair. This stupefies the fleas, causing them to drop and then they may be swept up and burned. Washing with a 3 per cent solution of creolin or a similar preparation is very effective. In the case of cats this should be followed by washing with warm soap and water in order to remove the creolin and thus avoid a possible slight burning. Dusting with pulverized naphthalene will drive the fleas from the animals, though it may sicken cats slightly for a day or two. Such measures are unnecessary if domestic animals are not allowed indoors.

One of the simplest and safest methods of destroying fleas in dwellings is fumigating with flake naphthalene, using five pounds to an average-sized room and closing it for 24 hours. The naphthalene may be spread out upon newspapers and used repeatedly. It is probable that dusting with sodium fluoride would give equally good results, although its use is not entirely free from danger. Both, especially the latter, could be used in cellars.

Calcium cyanide, either powdered or flake, preferably the latter, can be used to fumigate infested rooms or cellars at the rate of one pound to a thousand cubic feet of space for rooms or cellars which can be closed for at least several hours, preferably longer, and where adequate precautions against the deadly fumes can be readily taken. There should be thorough ventilation from the outside before anyone is allowed to enter the building or room.

General flea infestations usually originate in some dusty, undisturbed shelter. Cellars are frequently infested, and the first step should be to ascertain the conditions and stop the breeding by thorough cleaning or treatment with one of the above-mentioned materials. In the case of infested yards or lawns, all rubbish beneath buildings should be removed and burned, and the surface of the ground, frequently dry and dusty, should be treated with lime-sulphur or sprayed with an insecticide. The grass of the lawn should be cut as close to the ground as possible, the trimmings burned and the lawn kept well watered. An abundance of moisture is very detrimental to fleas. For a flea trap, see figure 19.

Rat fleas are not particularly troublesome to man, being only accidental parasites, and were it not for their tremendous importance in the dissemination of plague, they could usually be ignored. The

control of rat fleas is best effected by eliminating the host. This is one of the most effective methods in plague work. The rat-proofing of dwellings and other structures and the reduction of rat shelters to a minimum is of prime importance. Systematic trapping and poisoning is also very helpful. Rats are enormously prolific and this should not be overlooked. It has been estimated that the progeny from one pair of wild Norway rats would amount to 516,000 individuals in three years, assuming that breeding begins at the age of four months and that four litters of an average of six young, three of each sex, are produced each four months. This enormous increase appears well-nigh impossible, and yet at that rate there would be only 512 descendants at the end of the first 16 months, whereas there were actually obtained during this period at the Wistar Institute, Philadelphia, from a pair of Albino rats, 3800 descendants (Donaldson, 1925, p. 305), and that was by no means the limit, since several hundred rats were not allowed to breed at all during the latter months of the period. The obvious deduction is that food and shelter are very important and in rat eradication work the reduction of the available food supply to an absolute mean is essential.

CHIGGERS or SAND FLEAS, *Dermatophilus penetrans* Linn.

These insects, also known as jiggers or chigoes, are very annoying pests of the tropics in the New World and in Africa. They are very different from harvest mites, also known as chiggers and noticed on page 51. The insects are very small fleas which thrive in sandy regions and have a development similar to more common fleas. The females have the unpleasant habit of attacking man and burrowing into the skin, especially under the toe nails, where they develop to relatively enormous dimensions and produce a hundred or more eggs. They cause a very painful inflammation of adjacent tissues. The eggs are laid in the cavity and as soon as this occurs, the wound ulcerates and there is danger of a serious infection followed by blood poisoning or even death from tetanus.

Infestation by this troublesome insect can be largely avoided by wearing high boots or shoes and leggings. The insects should be removed from the wounds as soon as possible, preferably by enlarging the entrance hole with a needle so as to permit the escape of the entire insect. This should be followed by a dressing to promote healing. Bathing the infested parts with kerosene is also recommended.

BODY PARASITES

There are several insects grouped under this heading because they have considerable in common.

BEDBUG, *Cimex lectularius* Linn.

This insect (see fig. 20), has been shown capable of transmitting bubonic plague, South American trypanosomiasis, and one experi-

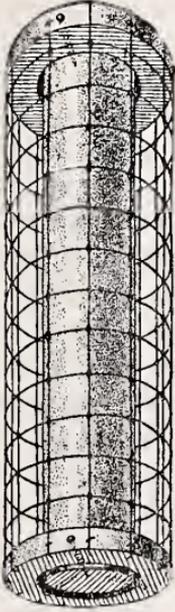


Figure 19 Flea trap. The central cylinder is removable and is covered with sticky fly paper. (After Bishopp)



Figure 21 Masked bedbug hunter, *Reduvius personatus*, an enemy of the bedbug; from above, about twice natural size. (After Howard)

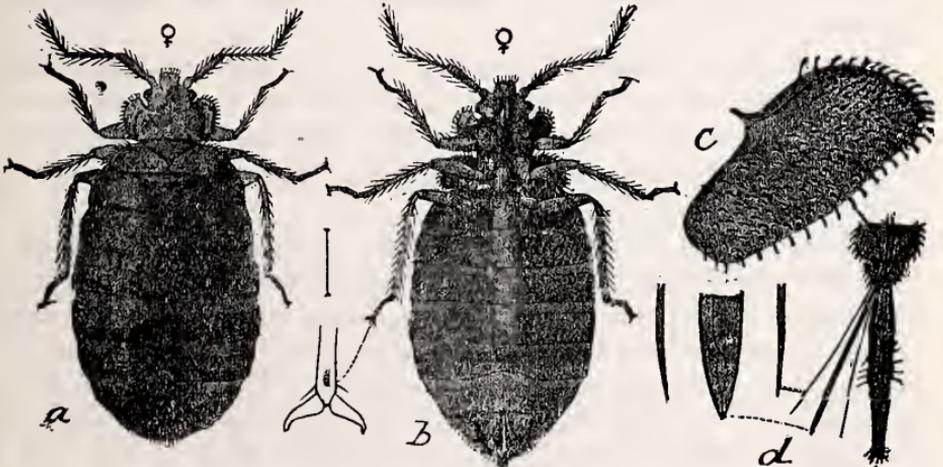


Figure 20 Bedbug, *Cimex lectularius*: A and B, adult females from above and below, gorged with blood; C and D, structural details. (After Marlatt)

menter has succeeded in transmitting by its bite European relapsing fever from mouse to mouse. The tropical bedbug, *Cimex rotundatus* Sign., when macerated and inoculated into a white mouse 32 days after feeding caused relapsing fever (Dunn, 1923, p. 350). It has been claimed that kala-azar, oriental sore, tuberculosis and even syphilis may be so carried. In spite of these possibilities, the bedbug has not attracted much notice as a general disease carrier, either because its opportunities are so limited or on account of the difficulty of establishing the part it has actually played.

The bedbug is nocturnal, feeding to repletion and then seeking shelter where it may remain for two or three days. The oval white eggs are deposited in cracks and crevices in batches of six to 50 or thereabouts. The yellowish white, nearly transparent young hatch in a week or ten days and approximately 11 weeks are necessary to complete development, although this is probably greatly modified by the degree of warmth and the abundance of food. It is stated that ordinarily one meal is taken between each of the five molts preceding maturity. The ability of these insects to live without food has an important bearing upon the prevalence and control of the pest. Newly hatched bedbugs, those which have had no opportunity of feeding, may live on an average 28.1 days, the maximum being 41 and the minimum 17 days. Partly grown individuals, captured and therefore with no record as to previous feeding, lived from 17 to 60 days and full-grown adults from two to 60 days. Unfed bugs at temperatures of from 60 to 65° F. may live for 136 days and after meals for 9 months. Unfed young bugs have been kept alive in a bottle for 75 days. These pests are also known to feed to a certain extent upon mice and some domestic animals and this habit may frequently explain the abundance of bugs in uninhabited dwellings.

Bugs frequently infest the nests of swallows and bats and while they resemble the true bedbug very closely indeed, they are different and rarely trouble people, although they sometimes invade rooms adjacent to nesting places. Occasionally chicken houses are badly infested by the true bedbug.

The elimination of cracks and crevices, loose wall-paper, wooden bedsteads and similar hiding places, is a great assistance in checking this pest. In the older types of dwellings cracks and crevices should be stopped and the joints of old-fashioned bedsteads treated liberally with kerosene, benzine or similar oils. Hot water can also be employed. A 5 per cent solution of carbolic acid kills bugs in 10 minutes. Medical turpentine with its own volume of soap suds

is very effective. A 6 per cent mercuric chloride solution kills all bugs it comes in contact with and though it is a virulent poison, the solution may be forced into cracks and crevices and the like infested by bugs without serious danger. Furthermore, on drying, a thin film of poison remains which will kill any bugs not hit by the spray. Fumigation with calcium cyanide, 1 pound to 1000 cubic feet of space, is effective where possible. The treatment should last at least several hours and preferably 10 hours to two days.

Consideration of the bedbug would be incomplete without reference to the "big bedbug" of the South, *Triatoma sanguisuga* Lec., a species which rather commonly attacks man and inflicts an exceedingly painful bite, due to the poisonous saliva apparently injected. This insect is carnivorous in habit and feeds upon insects as well as upon mammalian and human blood. It is reported as frequently occurring in poultry houses and as attacking horses in barns. The masked "bedbug hunter," *Reduvius personatus* Linn. (see fig. 21), widely heralded as the "kissing bug" about 1900, is a closely related species with similar habits. The bite of this species is exceedingly painful, the resulting swelling and irritation lasting sometimes for a week. Ordinarily it is beneficial, since the young prey upon other insects. This group of big bedbugs is particularly interesting, since a Brazilian species, *Cornrhinus megistus* Burm., very commonly attacks man in that section of the world and has been definitely associated with the dissemination of trypanosomiasis of man. It is characterized as pre-eminently a household insect, the eggs being deposited in cracks and crevices, and the young hatching in 20 to 40 days. The entire life cycle is estimated at 324 days. The bite of this species causes little pain. The same trypanosome develops in the common bedbug, *Cimex lectularius* Linn. and in *C. rotundatus* Sign., the period of infectivity being much shorter, however.

BODY LOUSE, *Pediculus corporis* DeGeer

This insect is the principal agent in disseminating typhus and trench fever, both diseases of cool temperate climates. The louse is also a vector of recurrent fever, an infection which on virgin soil exhibits a malignancy out of proportion to its comparatively harmless nature in countries where it has long been endemic (Trans. R. Soc. Trop. Med. and Hyg., 1925, 19: 256-64).

There is evidence that under certain conditions this insect may carry plague and the bacillus of typhoid fever has been found in

the blood of lice. It is suspected of carrying both leprosy and beri-beri.

Lice have been definitely associated with *impetigo contagiosa*, patients suffering from this affection quickly recovering after the elimination of the lice. One investigator has associated head lice with an eye disease, phlyctenular conjunctivitis. There are also records of lice being able in some manner to establish themselves under the skin and in the case of certain cutaneous lesions it is quite probable that lice are important agents in increasing the severity of the affection.

Louse bites produce minute haemorrhagic spots located chiefly over the neck, back and abdomen. These are accompanied by urticaria, the itching leading to scratching so that the skin appears scarred in a lineal manner by the finger. In tramps, chronic drunkards and vagabonds who may harbor lice for years, the skin over the most frequently bitten areas becomes rough, thickened and deeply pigmented. This condition is known as morbus errorum or vagabond's disease. Pediculosis alone may at times produce fever which has been attributed to cutaneous irritation and possibly to the toxic action of numerous louse bites. The melanoderma or skin pigmentation just mentioned may extend to the mucous membranes and be visible in the mouth, and this at times has led to a false diagnosis, it being considered Addison's disease. In pediculosis there may be extensive skin maculae, but in Addison's disease the pigmentation occurs in skin regions that are rich in natural pigment; there are no pedicular maculae on the mucous membrane and there are no pediculi present.

Available data indicate the somewhat general prevalence of lice among the poorer classes, particularly where crowding and insanitary conditions prevail. In the case of patients admitted to hospitals, the proportions may vary from about 1 to over 5 per cent.

This insect is very similar to the head louse, though it has different habits and is considered a distinct species. It is considerably larger than the head louse, has longer antennae, and is of a dirty white color. This parasite usually conceals itself in the folds of the clothing, deposits eggs along the seams and wrinkles, and passes to the skin only for the purpose of feeding, which latter is said to occur twice a day. It is the "gray back" of the Civil War and the "cootie" of the World War.

A female may deposit nearly 300 eggs, which latter hatch in from three to four days, maturity being attained in 15 to 18 days. Other authors give the duration of the egg period at eight to 10

days or even 10 to 12 days, and state that the eggs may remain viable away from the body for a period of 40 days. The areas favored for oviposition are, in the order of their importance, the fold of the trousers and the armpits, the wrinkles at the tail of the shirt, next are the trousers and shirt seams and then the neck. Eggs have even been found on the beads of rosaries. The insects accumulate where there is warmth, humidity and shelter. These parasites may survive separation from the human body for a period of nine days. They may penetrate dry sand or earth to a depth of 12 inches and live beneath it for four days.

Body lice may under certain conditions be blown a number of feet and occasionally infestations may occur in this manner. When at a greater distance than 15 to 18 inches from the skin they wander about aimlessly, although when not feeding the lice attach themselves to fragments of clothing, the latter a very probable explanation of typhous infection among doctors. Underfed or cold lice do not oviposit. The eggs are probably not laid on straw bedding under normal conditions since egg laying ceases at 76° F. and a daily fall of temperature to 61° F., even though it lasted for two hours only, caused a considerable reduction in the number of eggs. It is probable that hatching and oviposition would stop if at night all clothes were removed and placed where the temperature was 61° F. or lower and the bedding was left during the day in an unheated place.

Lice are able to live without food for two to five days at a temperature of 85° F. in moist air and from two to three days in dry air at 68° F. They live from three to six days in moist air and from two to four days in dry air, while at 60° F. they live respectively four to six and four to five days. The lice become rigid with cold at 10° F. but revive when the temperature rises. Dry heat at 104° F. will kill a gorged louse in six hours or a hungry one in two hours. Dry heat about 129° F. causes death after one-half to three-fourths of a hour. In practice one hour at 140° F. should be sufficient to kill all stages, since it is probable that none can survive an exposure to this temperature for 30 minutes.

There are records of body lice feeding upon head lice, crab lice, black ants and bed bugs, habits which make possible infestations in warm climates persisting much longer than suggested by the above data.

Vermicides. Naphthalene 96 per cent, creosol 2 per cent, and iodoform 2 per cent, appears to be one of the best and speediest killing powders, though it should not be used too freely as it is apt to cause severe smarting. The preparation should be used on the

portions of the garments most likely to be infested. It not only kills the lice but affords a considerable measure of protection for a period of five days. Commercial naphthalene is more active than the pure, its lethal power being dependent in great part on the presence of hydrocarbons and coal tar derivatives. Creosote is a slower insecticide and acts over a longer period and the iodoform greatly increases the adhesiveness of the mixture for clothes. A mixture of one part each of naphthalene and camphor with sufficient benzine to render them miscible and this in turn mixed with 3 parts by weight of sawdust is recommended as a preventive to be placed in small, flat sachets measuring one and one-half by two and one-fourth inches and worn next to the skin. Even a handful of finely powdered naphthalene put into the clothes through the opening of the neck and sleeping with the clothes on the body has been found to result in complete disinfestation, if done three times at four-day intervals.

Lice in clothes, bedding and the like may be destroyed by applying sufficient heat, either dry or moist, or by using chemicals. Ironing the seams of clothing with a very hot iron is effective, it being especially applicable to the outer garments. Steaming under pressure for 20 minutes will destroy all stages.

HEAD LOUSE, *Pediculus capitis* DeGeer

This is smaller than the body louse, with shorter antennae and is more frequently seen on children than adults. As a rule it occurs on the head, though occasionally it is found upon other hairy portions of the body and in heavy infestations may spread all over the body and clothing.

The female may lay over 100 eggs in about 30 days. The egg period is about six days and the lice require approximately 18 days to attain maturity. The eggs or "nits" are whitish, pear-shaped and fastened by their smaller ends to the hairs, especially those back of the ears. The lice produce a severe itching accompanied by the formation of an eczema-like eruption. When the infestation is severe the discharge from the pustules mats down the hair and scabs are formed under which the insects swarm. In such cases there may be a foetid odor. Girls are somewhat more liable to infestation than boys on account of their longer hair.

Contact with infested individuals, the clothes of such persons or even leaning against upholstered furniture in places frequented by such persons, may result in infestation.

Among school children the judicious use of a fine comb or the application of a tincture or extract of larkspur is usually effective. Kerosene, if applied with discretion, will destroy the insects without untoward effect.

CRAB LOUSE, *Phthirus pubis* Linn.

Pruritus is the first symptom calling attention to this louse. It may be violent and lead to much scratching day and night, although itching may be only moderate or almost absent. There are frequently bluish spots on the skin a sixth to half an inch in diameter, irregular in outline and most abundant about the abdomen and thighs. The fever and headache sometimes accompanying this infestation are possibly due to the toxic action of the louse.

The flattened, broad, whitish crab louse is very different from either the head or body louse and has not been associated with the dissemination of any disease. Its very stout legs are tinged with red and add greatly to the crablike appearance of the parasite. It lives on all the hairy portions of the body except the head and under exceptional conditions may be found on the head, although it displays a marked preference for the pubic regions and the armpits. The pear-shaped eggs are attached to the hairs and hatch in six to seven days, and in 15 days the lice are mature. This pest is able to live apart from its host under favorable conditions for 10 to 12 hours. There are two records of this insect occurring on dogs. Infestations have been contracted by using public water closets, and in unclean lodging houses, bath tubs and the like.

Repeated applications of mercurial ointment is the most satisfactory method of controlling this louse, although it is a dangerous poison and should therefore be used with discretion. Vaseline mixed with yellow precipitate is advised for the eyebrows and eyelashes.

COCKROACHES

There are several species of cockroaches (see figs. 22, 23) which may become extremely abundant in dwellings and are certainly highly objectionable on account of their filthy habits and contamination of food. The American cockroach, *Periplaneta americana* Linn., has been fed upon cultures of cholera and the disease germs recovered from the insect feces, in one instance 79 hours after feeding. Cockroaches have been observed to disgorge portions of their meals at various intervals after feeding, and in one case, as long as an hour after, cholera vibrios were found in the affected materials. It is quite possible that several of the cockroaches may

disseminate disease and they should certainly not be tolerated in hospitals or around sick in dwellings.

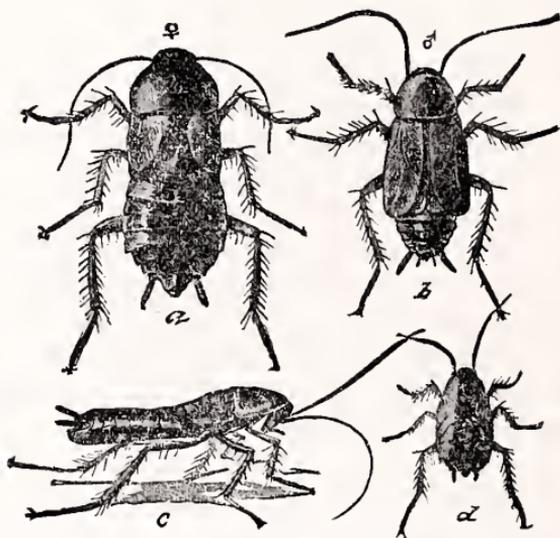


Figure 22 Oriental cockroach, *Periplaneta orientalis*: A and C, female from above and the side; B, male; D, a half-grown individual; all natural size. (After Marlatt)

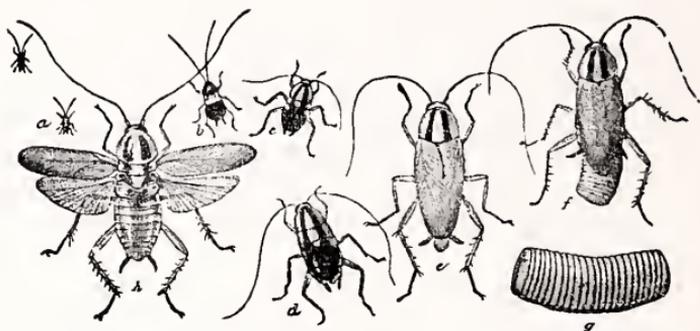


Figure 23 Croton bug, *Ectobia germanica*, A, B, C, D, successive stages in the development of the young; E, adult; F, female, with egg case; G, egg case enlarged; H, adult, with wings spread; all natural size except G. (After Riley)

Sodium fluoride diluted with equal parts of plaster of Paris or similar materials and strewn about the haunts of these insects, is a simple and very effective method of controlling these pests. Boric acid gives excellent results, but powdered borax or borax diluted with equal parts of naphthalene flakes has given very satisfactory results.

TSETSE FLIES

The tsetse flies, *Glossina* sp., have had a very important influence upon the development of certain portions of Africa, and even today considerable areas are depopulated or without domestic cattle because of the infections carried by these insects. Here, as in the case of other disease-carrying insects, the flies must first become infected before they are in a position to give the diseases to either animals or man, as the case may be.

These insects are brown or yellowish brown, some no larger than ordinary house flies and others larger than blowflies. They have biting mouth parts similar to those of other biting flies. The native wild animals of Africa are the normal hosts of these flies and the reservoirs of the deadly trypanosome diseases transmitted by them. Unlike most other flies, the development of the young is within the body of the mother fly, the larvae escaping and transforming immediately to the pupa in soft, dry ground. A single fly has been known to produce eight larvae or maggots in the course of 13 weeks. There are a number of species of tsetse flies which range across the central part of the African continent and several types of diseases are carried by these insects. See the Guide to the Study of Tsetse-Flies by Newstead, Evans and Potts (1924), for a comprehensive account of these interesting and economically important insects.

The deadly nagana of domestic animals caused by *Trypanosoma brucei* is carried by *Glossina morsitans* Westw. This disease makes it impossible to keep domestic animals in infested regions, and in certain seasons of the year they can not even be driven through such territory without danger of losing a considerable proportion of the stock.

The tsetse flies are of most importance because they are carriers of sleeping sickness, the most widespread of which is known as Gambian sleeping sickness and which is caused by *Trypanosoma gambiense*, an infection transmitted chiefly if not exclusively under natural conditions by *Glossina palpalis* Rob-Desv. This is the disease which has caused the depopulation of entire districts, the population of Uganda some 10 years ago being reduced during the preceding six years, it was estimated, from 300,000 to 100,000. There is a mild Nigerian sleeping sickness believed to be only a variety or strain of the more serious infection just mentioned. It likewise is carried by *Glossina palpalis*. The more recently recognized Rhodesian sleeping sickness is carried by *Glossina morsitans* Westw. Other species have also been recognized as carriers.

The large areas infested by tsetse flies, the numerous sources of infection in the native animals, and the generally primitive living conditions of the natives make the sleeping sickness problem very difficult. Governmental agencies have been investigating the problem for a number of years and as a result much has been learned concerning the flies, the infections and the possibilities of restricting the disease. The working out of practical methods of dealing with this situation is one of the big problems, if not the biggest, in that section of the world.

Control consists largely in reducing the breadth of contact, namely, restricting the probabilities of bites from infected flies, such as clearing up brush affording shelter to the flies, and in a few instances transporting entire populations from well-defined fly belts. The collection and destruction of flies or their pupae has been attempted on a small scale. Some protection can also be secured by wearing light colored clothing which is not particularly attractive to the insects. The destruction of the principal native fly hosts has also been considered, though not carried out on an extensive scale, owing to economic and other considerations.

LEISHMANIASIS

There are several serious affections grouped under this name, and while these are rarely found in this country, their occasional occurrence justifies a brief notice.

Kala-azar was epidemic in India about 1870, entire villages and settlements being depopulated. An insect or insects are the probable carriers and there is considerable evidence implicating the Indian bedbug, *Cimex rotundatus* Sign., as a carrier, possibly the principal vector.

Infantile kala-azar, prevalent in countries bordering the Mediterranean, closely resembles true kala-azar but differs in attacking infants and children almost exclusively. The Mediterranean infection occurs in dogs and it is believed that the dog flea may be the transmitting agent.

Oriental sore is another of these infections prevalent from India through Persia, Syria and Arabia and south of the Mediterranean westward to Morocco. It is believed to occur in many tropical South American cities, and one or more insects may serve as intermediate hosts, the bedbug being strongly suspected.

Espundia or American Leishmaniasis occurs in a number of the tropical South American countries and is particularly horrible because it attacks the skin and the mucous membranes of the nose and

mouth cavity. The slow progressive infection may result in the destruction of much of the tissue adjacent to the nasal passages, followed ultimately by death. The transmitter is unknown, though Tabanids have been suggested as probable carriers.

SCABIES AND MITE RASHES

The first symptom of scabies is intense itching, which increases when the patient is in bed. The irritated areas show characteristic sinuous lines at first whitish but later blackish, these marking galleries inhabited by the burrowing mites, *Sarcoptes scabiei* DeG. The galleries may have a length of two inches, and firm, small, projecting vesicles about the size of a pin head are produced by the secretions from the feeding mite. Itching is followed by scratching and as a result various complications may develop. The attack does not usually extend to the face. In severe cases considerable areas of the body may be infested and the general health of the individual be seriously affected. Early symptoms develop some eight or ten days after exposure to infestation. The disease is cosmopolitan and occurs most frequently among the lower classes.

Several other species of mites produce uncomfortable and sometimes serious irritations, generally diagnosed as rash. The harvest mites or chiggers, *Trombicula tlalzahatl* Murray, are small, pink creatures, very different from the chiggers or sand fleas mentioned elsewhere. These harvest mites are mostly southern, occur upon vegetation of different kinds, usually in shady situations, and are most likely to attack in the vicinity of the ankles although they sometimes drop from trees and shrubs and establish themselves upon the neck or other parts of the body. The young mites are supposed to burrow into the skin, though careful studies by Dr H. E. Ewing (1921, p. 1), show that the hooked and barbed mouth parts only are thrust into the skin. He also demonstrated that the mites are much too large to enter the pores of the skin. These pests produce small, red spots which later become surrounded by a congested area of from less than one-fourth to one-half or three-fourths of an inch in diameter. The harvest mites occur in the Gulf States northward to New Jersey and Illinois, the distribution in the East being over very extensive sections, while in Iowa they occur only in relatively small areas. Around Washington, D. C., they are usually found in heavy growth or wild brush or blackberries, and do not occur in cultivated fields or where the ground is bare or in well-kept parks and lawns. Chiggers have been found upon black and garter snakes and several others (Miller, 1925 a, p. 345 and

1925 b, p. 112), probably the natural hosts of American species. The wearing of high shoes or the dusting of hoisery with flowers of sulphur or a mixture of equal parts of flowers of sulphur and any talcum powder affords very satisfactory protection against these pests. Dr H. E. Ewing (1925, p. 827) has demonstrated the efficacy of sulphur-impregnated clothing, both inner and outer garments being treated with a solution composed of one-fourth pound of naphtha soap, one gallon of water and one-fourth pound of flowers of sulphur, the clothing being dipped in the solution, wrung out and dried on the line over night. In addition, he has devised "coveralls" which with the use of puttees and special sleeves prevent the pests gaining access to the ankles and wrists.

Another mite attack is closely associated with wheat and straw infested by joint worm or grain affected by the angoumois moth. The mite, *Pediculoides ventricosus* Newp., is microscopic in size and when abundant may be easily detected as a yellowish mealy powder dropping from the infested grain or straw. It is primarily beneficial in that it preys upon two important grain pests and only occasionally troubles man. It produces, like the chigger mite, a dermatitis which may be diagnosed as rash and attributed to a number of causes other than the true one. This trouble is particularly likely to follow sleeping upon mattresses stuffed with infested straw or the handling of infested grain, and there are records of such affections following the unloading of Egyptian cotton seed. This mite has also been associated with epidemic asthma.

Treatment for scabies usually consists in softening the skin by friction with soap and water, followed by a warm bath and then applying something to kill the mites, such as the official sulphur ointment of the United States pharmacopoeia. In the case of a severe infestation it may be necessary to repeat the treatment three or four days later in order to kill the mites which have hatched from eggs.

Treatment for the harvest mites or chiggers consists of prompt bathing, if exposure is suspected. Applications of hot water containing salt or strong soap are advised and where exposure is unavoidable, sulphur rubbed or dusted over the legs and ankles is most satisfactory. Alkaline solutions counteract the acid poison. Cooling lotions may well be applied locally to reduce irritation.

MITES AS ENDOPARASITES

There are records of different species of mites living for example in the intramuscular and subcutaneous connective tissues of fowls, in their air sacs, in the nasal mucous membrane of the seal and in the lung of a species of *Cynocephalus*. It is only a step from this to infestation of man.

Miyake and Scriba recorded in 1893 a mite in the urine of a Japanese suffering from fibrinuria complicated with chyluria and haematuria. It was obtained in urine drawn from the bladder, the species being described as *Nephrophages sanguinarius*.

Dr W. E. Carnegie Dickson records (1921, p. 25) two cases of mite infestation in which the organism was found in urine drawn from the bladder. In the first instance the mite was identified as *Tyroglyphus farinae* DeG., a species common in flour, grain, stored foods and the like, and the second was determined as a species of *Tarsonemus*.

There appears to be no reasonable question as to the three species of mites actually being found in the bladder or urinary ducts. The probabilities are that all the infestations were casual and the result of abnormal conditions not apparent in the original accounts.

ROCKY MOUNTAIN FEVER TICK

This tick, *Dermacentor venustus* Banks, is rather generally distributed in the Pacific Northwest, although cases of spotted fever have been largely restricted to Idaho, western Montana and Wyoming, and eastern Washington and Oregon. The disease is caused by the transmission of a specific infection, the tick being the carrier.

The seasonal incidence of spotted fever occurs almost wholly in the spring months and corresponds to the period of activity of the ticks. The incubation period is from three to nine days. The onset of the disease is usually accompanied by a chill, and from the start there are severe, general pains referred to the bones and muscles, back and joints. Pains in the calf muscle and large joints and lumbar region of the back are most prominent. Headache is common and usually severe. After the first chill the temperature rises fairly rapidly and reaches 102° F. to 104° F. the second day. The rash usually appears on the third, fourth or fifth day and shows first on the wrists, ankles and back. It consists at first of rose-colored macules not elevated, 1 to 4 or 5 mm in diameter and disappearing upon pressure. The spots soon become deep red or

purplish in color. Ticks may remain infective for many months, and although *D. venustus* appears to be the only transmitter under normal conditions, experiments have shown that others may carry the infection.

The Rocky mountain tick, a reddish brown species with black and silvery lines, has a number of mammalian hosts. The ground squirrel is the most important host of the larva and nymph and the next are the yellow-bellied chipmunk and the pine squirrel. The woodchuck, snowshoe rabbit, wood rat, white-footed mouse, meadow mouse and side-striped ground squirrel are also of considerable importance. In eastern Montana the jack rabbit is considered the most important wild host of the adult. It also harbors nymphs and larvae, and is the only animal which serves as a host for all three stages.

Like most other ticks, this species has four distinct stages, the egg, the larva, the nymph and the adult. Fully engorged females, approximately one-half an inch long, deposit from 2000 to 4000 eggs. The larvae feed for three to eight days on small mammals, then drop and seek protected places, and after a quiescent period of six to 21 days develop into eight-legged nymphs. These may winter either unengorged or engorged. They also feed upon small mammals for a period of three to nine days, desert the host and in from 12 to 14 days transform to adults. These feed in the spring months before hot weather almost wholly on large animals, such as horses and cattle. The life cycle is completed in from two to three years. The adult ticks and sometimes the nymphs carry the infection, obtaining it from native hosts.

It is quite possible, owing to the long period of infectivity, for these Rocky mountain spotted fever cases to appear in distant sections of the United States. There would be little probability of an infection of local mammals and the establishment of another infected area, except possibly in sections where ticks were unusually abundant, as for example west of the Cascades and Sierras in Oregon and California where the Pacific wood tick, *D. occidentalis*, frequently attacks man. Control measures consist largely in reducing tick infestation and destroying native hosts so far as may be practicable.

An extended account of the disease and the tick carrying it appears in the *Journal of Medical Research*, 41:1-197, November 1919.

Several other species of ticks are known carriers of disease. The African *Ornithodoros moubata* Murray, very common in shaded places and in the dirty, thatched houses of natives, is a

vector of relapsing fever, and a related species, *O. savignyi* Aud., attacks man, camels and horses and is regarded as the carrier of the Indian form of relapsing fever. The Persian *O. tholozani* Lab. and Megn. is a proved carrier of African relapsing fever in that country, and *O. lahorensis* is probably a carrier of the same disease. The Mexican and Central American *O. talaje* Guer. is the transmitting agent of relapsing fever in those countries.

BIBLIOGRAPHY

Alcock, A.

1920 Entomology for Medical Officers; 2d ed. p. 1-347

Austen, E.

1911 African Blood-Sucking Flies; p. 1-317. British Museum Publications, London

Bacot, A.

1914 A Study of the Bionomics of the Common Rat Fleas and other Species Associated with Human Habitations with Special Reference to the Influence of Temperature, and Humidity at Various Periods of the Life History of the Insects. Jour. of Hygiene, Plague Supplement III, p. 447-654

Barnett, J. F.

1927 Black Flies, Insect Pest Survey Bulletin, v. 7, p. 50

Bishopp, F. C., Cook, F. C., Parman, D. C. & Laake, E. W.

1923 Progress Report of Investigations Relating to Repellents, Attractants and Larvicides for the Screw-Worm and other Flies. Jour. of Econ. Ent. v. 16, no. 2, p. 222-24

Chandler, A. C.

1922 Animal Parasites and Human Disease. Third Edition, revised, 1926, p. 1-528

Dickson, W. E. Carnegie

1921 Mites as Internal Parasites of Man. Jour. of Trop. Med. and Hygiene, 34, p. 25-27

Doane, R. W.

1910 Insects and Disease, p. 1-227

Donaldson, Henry H.

1925 On the Control of the Rat Population. Science, N. S., 61:305-6

Dry, F. W.

1921 Trypanosomiasis in the Absence of Tsetse and a Human Disease possibly Carried by Simulium in Kenya colony. Bul. Ent. Research, 12:233-38

Dunn L. H.

1923 The Tropical Bedbug in Relation to the Transmission of Relapsing Fever in Panama. Amer. Jour. Trop. Med., 3:345-50

Ewing, H. E.

- 1921 Studies on the Biology and Control of Chiggers, U. S. Dep't Agric. Bul., 986 p. 1-19
 1925 Sulphur Impregnated Clothing to Protect against Chiggers. Jour. Econ. Ent. 18:827-29

Fantham, H. B., Stephens, J. W. W. & Theobald, F. V.

- 1916 The Animal Parasites of Man, p. 1-755

Felt, E. P.

- 1917 Household and Camp Insects. N. Y. State Mus. Bul. 194, p. 1-80

Fox, Carroll

- 1925 Insects and Diseases of Man, p. 1-349

Fox, Carroll & Sullivan, E. C.

- 1925 A Comparative Study of Rat-Flea Data for Several Seaports of the United States. Public Health Reports, v. 40, no. 37, p. 1909-74

Graham-Smith, G. S.

- 1913 Flies in Relation to Disease, Non Blood-sucking Flies, p. 1-292

Hall, M. C.

- 1920 A Note Regarding Myiasis, Especially That Due to Syrphid Larvae. Research Laboratory, Parke, Davis & Co., v. 7, p. 65-69

Hegner, R. W., Cort, W. W. & Root, F. M.

- 1923 Outlines of Medical Zoology, p. 1-165

Hegner, R. W. & Taliaferro, W. H.

- 1924 Human Protozoology, p. 1-513

Herms, W. B.

- 1915 Medical and Veterinary Entomology, p. 1-378
 1925 Ophthalmomyiasis in Man Due to *Cephalomyia (oestrus) ovis* Linn. Jour. Parasitology, 12:54-55

Hindle, E.

- 1914 Flies in Relation to Disease, Blood-sucking Flies, p. 1-386

Howard, L. O., Dyar, H. G. & Knab, F.

- 1913-17 The Mosquitoes of North and Central America and the West Indies. 4 v.
 V. 1 Text p. 1-523
 V. 2 Plates p. 1-150
 V. 3 Text p. 1-523
 V. 4 Text p. 524-1004

Howard, L. O.

- 1923 A Fifty-Year Sketch of Medical Entomology. Smithsonian Report for 1921, p. 565-86

King, W. V. & Bradley, G. H.

- 1926 Airplane Dusting in the Control of Malaria Mosquitoes. U. S. Dep't Agric., Dep't Circular 367, p. 1-115

Kirby-Smith, J. L., Dove, W. E., & White, G. F.

- 1926 Creeping Eruption, Archives of Dermatology and Syphilology, v. 13,
p. 137-73

LePrince, J. A., & Orrienstein, A. J.

- 1916 Mosquito Control in Panama, p. 1-335

Miller, A. E.

- 1925a The Native Host of the Chigger, Science, n. s., 61:345-46
1925b Chiggers. Ohio Agric. Exper. Sta. Bimonthly Bul. X, no. 7,
p. 112-14

Newstead, Robert, Evans, Aliven M. & Potts, W. H.

- 1924 Guide to the Study of Tsetse-Flies, p. i-xi, 1-268, plates 28, maps 4

Nuttall, G. H. F., Warburton, C., Cooper, W. F. & Robertson, L. E.

- 1908-15 Ticks, A Monograph of the Ixodoidea, parts I-III
1918 Lice and Disease. Jour. Parasitology, 10:1-188, 375-586

Parker, G. H.

- 1922 Possible Pedogenesis in the Blow-Fly, *Calliphora erythrocephala* Meigen. Psyche, v. 29, no. 4, p. 127-31

Patton, W. S. & Cragg, F. W.

- 1913 A Text Book of Medical Entomology, p. 1-764

Patton, W. S.

- 1921 Notes on the Myiasis-producing Diptera of Man and Animals. Bul.
Ent. Research, 12:239-61

Patton, W. S. & Cookson, H. A.

- 1925 Cutaneous Myiasis in Man Caused by *Musca domestica*. The
Lancet, June 20, p. 1291

Pemberton, C. E.

- 1926 The Field Rat in Hawaii and Its Control. Bul. 17, Hawaiian Sugar
Planters Association, p. 1-46

Pierce, W. D.

- 1921 Sanitary Entomology, p. 1-518

Riley, W. A. & Johannsen, O. A.

- 1915 A Handbook of Medical Entomology, p. 1-348

Stokes, J. H.

- 1914 A Clinical, Pathological and Experimental Study of the Lesions
Produced by the Bite of the "Black Fly" (*Simulium venustum*). Jour.
Cutaneous Diseases, 31:751-69, 830-56

Ticho, A.

- 1923 Ophthalmomyiasis. Brit. Jour. Ophthalm., 7:177-82

Von Geldern, C. E.

- 1927 Systemic Effects following the Sting of *Epyris*, Science, n. s., 65:302

White, G. F. & Dove, W. E.

- 1926 Dogs and Cats Concerned in the Causation of Creeping Eruption.
Official Record, U. S. Dep't of Agric., v. 5, no. 43, p. 6

DISPERSAL OF INSECTS BY AIR CURRENTS

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DISPERSAL OF INSECTS BY AIR CURRENTS

Since success in the widespread efforts to control the dissemination of injurious insects by the establishment of quarantine regulations, both state and national, depends in large measure upon the possibility of preventing the spread of dangerous species, anything bearing upon the problem is of practical importance.

The following pages are devoted to a critical examination of the evidence relating to the part winds play in the spread of insects, using some recently gained facts concerning air currents in the interpretation of available data. Although much of the entomological phases has been known for years, it is now possible to apply thereto later knowledge gained in aviation and in pertinent meteorological investigations, together with recent studies made in connection with gipsy moth control work conducted by the New York State Conservation Commission.

METEOROLOGICAL DATA

Certain facts relative to air currents should be discussed at the outset, since they have an important bearing upon the movements of various insects.

General or Normal Wind Velocity

It should be kept in mind that the velocity of winds near the surface of the earth may be and frequently is quite different from that of upper air currents. The balloon work of the New York State Conservation Commission indicated an average velocity for balloons recovered within 24 hours of the time of liberation in 1923 of a little less than 18 miles an hour, the averages for various stations ranging from 14 to 27 miles an hour, while one balloon cover 65 miles in an hour and another the same distance at the rate of 100 miles an hour. The longest drift in 1923 was nearly 400 miles, seven balloons covering from 110 to 145 miles. In 1924 the maximum was nearly 775 miles. Meteorologists inform us that upper air currents may attain a velocity of 100 or even 200 miles an hour. It is easy to see from the above that insects remaining in the air for some hours could easily be transported considerable distances, particularly as some of the high velocities as compared with surface standards are not necessarily accompanied by marked turbulence.

The effects of winds were recognized early by Humboldt (1850, p. 232). He states that small singing birds and even butterflies are often met with at great distances from shore, during storms blowing off land. He adds that insects are involuntarily carried by

vertical ascending currents into the higher regions of the atmosphere to elevations of 17,000 to 19,000 feet above the plains and states that Don Mariano de Rivero observed minute balls of grass-haums, a species of *Vilfa*, carried from the valley of Caracas to the summit of the Silla, an elevation of 5755 feet, the numerous drifting masses being at first mistaken for a flock of small birds. He also records the common occurrence of insects on high mountains at elevations of 16,000 to 19,000 feet.

Professor T. Bainbrigge Fletcher, imperial entomologist, India, from faunal studies in that section of the world, holds that upper air currents are important factors in the distribution of insects.

The recent gliding records of Europe are worthy of notice. If man, an animal without an inherited provision for flight, can remain in the air for upwards of 14 hours, drift for about 50 miles, and rise to an elevation of nearly 1800 feet; should we not expect as much from species nature has endowed with wings? Soaring is well known among birds and is certainly practised to some extent by insects. One objection possibly is the fact that many insects do not venture from shelter during windy periods. This plainly applies to observations made near the surface and may be true to a much less extent at some elevation. The gradual rise of many of our balloons, even when they ascended to considerable heights, was somewhat gentle and not suggestive of turbulence.

The crepuscular species are less likely to be carried by the winds, though this presumably occurs rather commonly with certain species, notably the cotton moth, *Alabama argillacea* Hubn. Here we have an insect breeding in immense numbers and completing its transformations within so short a time that defoliated cotton fields would presumably be so nearly bare at the time the moths emerge as to produce convectional currents which would carry the insects into the upper air and thus make distribution by the winds relatively easy. In the case of this group it is presumably necessary not only that there be enormous numbers of the insects but also defoliation or near defoliation of somewhat sizable areas in order that favorable upward air currents may be induced.

The strictly nocturnal insects would ordinarily fly at such times and under such conditions that winds would not be particularly helpful in distributing them. Whether this be simply a coincidence or not, it is a fact that extended wind distribution of nocturnals appears to be comparatively rare.

The somewhat common occurrence of lowland species upon mountain tops is discussed by Tutt (1901) in some detail. He states

that lowland beetles are carried up by ascending currents of air, and adds that some of the most sedentary beetles during their flight periods often rise to high altitudes and from thence may be carried to very high altitudes by vertical currents, positions which would permit drifting or flight for immense distances.

Professor E. B. Poulton (1904, p. xxiv-xxv) suggests that the presence of hosts of insects occasionally observed on mountains may be due to an instinctive gathering at such places, a habit which would facilitate pairing, referring in connection therewith to the well-known flights of certain ants. There are undoubtedly mating activities at these elevations during periods when temperature conditions permit. It would seem that these are largely incidental, that they would occur anywhere there were swarms of insects and that the real explanation is a physical one, somewhat as outlined above.

G. V. Hudson (1905, p. 334-36) presents data from New Zealand and is inclined to agree with the solution offered by Professor Poulton.

Winds of High Velocities or Gales

There are some records of insects, notably the blue page moth mentioned elsewhere, and birds being carried far from their normal courses by wind storms. These occur from time to time in various parts of the earth and are presumably of somewhat minor importance, as will be suggested later, in the transportation of insects.

Direction of Prevailing Winds

Recent meteorological observations in the United States have shown strong westerly components in the upper air currents, these being well marked in the case of a series of balloons liberated several years ago west of the Mississippi river and recovered in widely separated localities in the central and eastern United States. These balloons were released to gain information respecting the upper air currents. Nearly 20,000 toy balloons, released under the direction of the New York State Conservation Commission, were inflated for a minimum buoyancy for the purpose of obtaining information respecting the lower air currents, since it is believed that these latter were the more important in carrying young caterpillars of the gypsy moth, *Porthetria dispar* Linn. This work was continued during the occurrence of young gypsy moth caterpillars for three seasons and demonstrated, as in the case of the earlier work with larger balloons, a general prevalence of westerly winds. In the case of western New England and eastern New York there were

strong northerly and southerly components along the Berkshires and the Green Mountains.

Checking these balloon records with meteorological records from a number of adjacent federal stations and also a series of temporary weather stations, showed substantial agreement between the data obtained in these various ways.

The work with toy balloons showed that even with a low buoyancy it was not uncommon for a balloon to drift some distance at a low elevation and then rise, usually rather gently, to a height of several hundred feet, possibly 1000 feet or more, this increase in elevation being due in most cases to upward convectional currents produced by a heated land surface or the sunny slope of a range of hills.

Convection and Other Upward Air Currents

It is well known that warm currents rise from heated surfaces, but the extent of these movements does not seem to have been fully realized prior to the advent of the airplane. It is now well recognized that such comparatively insignificant features in the landscape as state roads produce convection currents which may be distinctly felt 1000 feet above the surface. Convectional currents in the warmer parts of the earth may easily attain 15,000 feet.

There are always strong updrafts in mountainous regions, even if these are not accentuated by heat from the sun. It is pointed out by Clark (1925, p. 111) that waves are rows of little hills and that the wind on striking these is deflected up with considerable force. He adds that soaring and gliding birds take advantage of these upward currents and are restricted largely to the mountains and the ocean. He even calls attention to the supporting effect of the air behind a moving steamer, the upcurrent being sufficiently strong to support almost motionless albatrosses. If these winds will support birds, insects with their relatively greater wing expanse would be lifted even more readily and it is believed that these upward currents are important in promoting the distribution of insects, since they serve as elevators, as it were, and carry many species into the upper air where horizontal winds of high velocity are common or to the summits of high mountains where they are dropped in large numbers in areas of comparative calm, as for example on glaciers or even, as recently recorded, in such an unlikely place as the crater of Vesuvius. The height of these upward currents is indicated by the fact that aviators find bumpy conditions up to 3000 or 4500 feet, approximately the lower cloud level, while horizontal currents prevail at greater elevations and flying is relatively smooth.

The Physical Effects of Streams, Lakes, Oceans and Mountain Tops

These natural features produce changes in temperature, usually a lowering, consequently there are frequently descending currents caused by the cooler air seeking its level over water surfaces or coming nearer to the surface on hills and mountains. These influences, sometimes almost imperceptible, tend to bring anything floating or drifting in the air nearer to the surface of the earth. They explain to a considerable degree the dropping of many insects into streams, even relatively small ones, and the somewhat high proportion of balloons returned from localities along the New England coast and the New Brunswick and Nova Scotia littoral.

It is well known that winds tend to follow valleys and that in the Connecticut and Hudson river valleys, for instance, there are decided north and south winds. These conditions exercise a marked influence upon the dissemination of insects in such areas.

Dispersive Effects

It is well known that winds are frequently extremely variable. The extent of this is indicated somewhat by the balloon work of 1923, only 25 per cent of the balloons recovered being returned from points lying in approximately the same direction as the original drift. This variability is of considerable importance in the case of distribution from somewhat restricted areas and may easily explain the appearance of individuals hundreds of miles from the nearest breeding area and also the relatively slow spread of certain forms carried by the winds, since the dispersion might in most cases insure such a scattering as to make it impossible for the species to establish itself, except under extremely favorable conditions.

Thunder Storms or Unusual Atmospheric Disturbances

Birds are sensitive to atmospheric disturbances accompanying storms and many observations indicate reactions of the same nature among insects. Many insects are driven to cover by cloud and storm, this being particularly true of butterflies. The tendency to seek shelter in the face of a storm is illustrated by Gätke's account of the behavior of dragon flies in Heligoland. There are also records of certain moths and aphids apparently allowing themselves to be swept up into the air by the air currents preceding the outbreak of a storm.

Barometric Pressure

Several records of notable invasions by migratory grasshoppers or locusts are reviewed by Professor C. B. Williams (1923, p. 222-24) and the probabilities of the movement of these insects being affected by barometric pressure are given careful consideration. Since winds blow toward lows, a lowering of the barometer would be favorable for the drifting of insects toward the center. It hardly seems as though changes in pressure alone would have a determining influence upon the movement of insects, although it can be easily understood how the conditions near the center of a storm area would very likely have a profound influence upon insect life, as well as upon larger animals.

Temperatures

The effect of temperatures upon insects in the air deserves serious consideration. It is well known that coolness causes inactivity among most insects and it is more than probable that the marked chill of winds sweeping over moderate to high elevations, especially the latter and over glaciers, is responsible in large measure for the enormous collections of insects so frequently observed on mountain tops and glaciers. There are records of Rocky mountain locusts being shattered by dropping swiftly from high moving swarms, quite possibly the result of the chilling inevitable at some height in the shadow of even a small cloud or from coming in contact with a cool strata of air. The collections of insects along the shores of lakes and the somewhat large proportion of balloons recovered along the margins of streams, lakes and the ocean may be attributed in considerable part at least to the falling air currents induced by the lower temperatures so common over water.

INSECT POPULATION OF THE AIR

The fact that a very large proportion of the species of insects are provided with wings is indubitable evidence of adaptation to aerial existence, and it therefore follows that we should expect a certain aerial population. This presumably varies widely from different causes. In the temperate zone it rises to a maximum in the warmer midsummer months and drops to a minimum, in fact practically to nothing, in midwinter. There are also marked differences in the insect aerial population in the spring or fall as compared with the summer.

The evidence of a definite aerial population is suggested by the following: There are a number of records of insects appearing in

abundance upon vessels miles and in some cases many miles from land and also of their occurring rather commonly at lights distant from land, such as isolated lightships or lighthouses. Professor Wood-Jones is of the opinion that both dragon flies and moths fly away from land in an irresponsible way and he has observed moths coming nightly to a ship's light when she was lying 20 miles from shore. The observations of Commander Walker in relation to the occurrence of the monarch butterfly somewhat commonly in the South Pacific and miles from land, also support this interpretation. The occasional finding of immense numbers of insects in the drift along a lake or ocean beach is another indication of an aerial population, unless we assume that these occurrences can be accounted for only by the insects being swept out over the water by violent storms, an explanation which would not apply to many of the appearances of insects at vessels and lights distant from land. The same irresponsible drifting is indicated by the appearance of insects in deserts miles from any suitable habitat (Williams, 1926, p. 282).

The height or depth of this aerial insect population is indicated by the finding of mosquitoes and other insects at an elevation of 3000 feet or more above the surface. Granting that the records of insects at such heights above the surface indicate a condition more general than has heretofore been realized, it is comparatively easy to see how a sudden drop in temperature in the upper air, caused possibly by a cool current dropping nearer to the surface of the earth, might easily result in forcing the insects somewhat sparsely distributed through a layer of air of 500 to 3000 feet in depth down to a layer with a depth of less than 50 feet, the insects presumably continuing their flight in the same general direction as when occupying the deeper layer. Such a concentration could easily produce conditions which to the observer on the surface of the earth would suggest a marked and determinate migration, and these conditions would most likely occur in the spring and the fall with the normally, somewhat rapid fluctuations from cool to warm and vice versa. With the preceding in mind, it is not even necessary to assume that the large swarms of monarch butterflies so frequently seen in the fall are necessarily migrating south. They may have been driven from the upper air by cool winds and the general trend would naturally be south rather than north in that season of the year, because that is the direction toward warmth and comfort. The movement, as suggested elsewhere, may be simply a modification of a swarming instinct prior to hibernation.

It is well known that the number of insects in the air varies greatly in different parts of the day. It may not be so generally recognized that the daily periodicity of flight, diurnal, crepuscular and nocturnal, may have a very material bearing upon the probabilities of wind dissemination. It is presumable that effective widespread distribution can occur only when insects are found in immense numbers under conditions which would facilitate their being carried by the air currents somewhat above the surface of the earth, a distance of 500 feet or more. Species which develop in immense numbers on restricted areas and fly at a time when convectional currents are likely to occur, are more likely to be carried by winds, provided there are no instinctive or other limitations which either lead them to keep near the surface of the earth or else prevent their being carried to some heights.

The possibilities of collecting at from 40 to 200 feet above the surface of the earth are suggested by Dr H. B. Weiss (1927) in the lists of species captured in the lookout stations of the New Jersey Forest Fire Service.

ALTITUDES REACHED BY INSECTS AND PLANT SPORES

Allusion has been made to the fact that it would be comparatively easy for insects with the aid of convectional currents to attain considerable heights. Professor Stanley B. Freeborn of California informs us in a recent communication that he met swarms of a mosquito, *Aedes dorsalis* Meign., at an elevation of about 3000 feet in the Central Sacramento valley in 1919. Stewart Lockwood states in a recent letter that *Melanoplus atlansis* Say was observed by C. L. Corkins in North Dakota at an elevation of 2000 feet, although the bulk of the grasshoppers were several hundred feet lower. A note in the April 1925 issue of the *Journal of Economic Entomology*, page 437, records honey bees flying around a balloon and feeding on chocolate at an elevation of 900 meters, though at 2000 meters, they were unable to fly, possibly and perhaps mostly on account of the low temperature. These records leave no doubt that under certain conditions bees, mosquitoes, grasshoppers and other insects may attain considerable elevations in the air. This is very different from finding insects on high mountains.

A consideration of the preceding data led the writer to believe that collecting in the upper air was possible. Through the interest of United States Senator James W. Wadsworth and the hearty cooperation of Colonel B. D. Foulois, commanding officer, Mitchell Field, and his associates, an airplane trap with a sectional area of

some 8 by 10 inches was devised, attached to the lower wings of a J. N. plane and so arranged that glass slides smeared with tree tanglefoot could be exposed at given altitudes and for a definite time. Below is given a record of captures. There were a number of other flights without taking insects.

Insect Captures in a Trap on an Airplane

Date.....	August 30, 1926....	August 31, 1926....	September 4, 1926
Pilot.....	Cadet Dixon Allison.	.....	Cadet Dixon Allison
Observer.....	Private McCabe....	.....	.....
Type of plane...	J. N.	J. N.	J. N.
Wind direction..	West.....	N. W.	N. N. E.
Wind velocity...	3000 ft, 38 m.p.h...	1000 ft, 22 m.p.h...	1000 ft, 22 m.p.h.
Wind velocity, ground.....	15 m.p.h. ....	.....	16 m.p.h.
Temperature....	3000 ft, 66° F.....	3000 ft, 62° F.....	1000 ft, 64° F.
Temperature ground.....	80° F.	84° F.	70° F.
Course flown....	Long Beach-Oyster Bay	Long Beach-Oyster Bay	Freeport-Port Washington
Insects captured.	1 Mesogramma, 3000 ft	1 Hylemyia cilicrura 3000 ft	1 Chrysotus 1000 ft
Time captured..	10.02-10.20 a.m.	10.52-11.02 a.m.	9.20-9.32 a.m.

It is interesting to note that all of the specimens taken were small and it should also be observed that the collecting surface in comparison with the extent of the atmosphere was extremely small. Dr J. M. Aldrich of the United States National Museum, who kindly identified the species expressed much doubt as to the *Chrysotus* ever occurring at a great height in the air. He adds that all the species of this genus are found close to the ground and close to shade although they like to come out and rest on foliage in the sun from time to time. It seems incredible to him that they ever occur in nature more than ten feet above the ground. The construction of the trap and its location on the plane is such that it seems impossible that this fly could have been taken up with the machine. This is perhaps one of the many surprises likely to develop with further exploration of the upper air.

More recently there has come to hand a record of a wasp impinging upon the wind shield of an air liner at 6000 feet and of numerous small insects at 4000 feet.

The record of plant disease spores (Stackman, 1923, p. 599) occurring abundantly at an elevation of 11,000 feet, represents an extreme. It should be borne in mind that spores drift in the air. They certainly possess no powers of flight.

Professor F. V. Theobald of the Southeastern Agricultural College, Wye, Kent, England, in a letter dated February 2, 1927, states that during the World War, at his suggestion, a number of aphids, *Aphis rumicis* and *Anuraphis helichrysi* were captured with sticky fly-paper on an airplane at an elevation between 1000 and 1600 feet, he having previously to this observed aphids sticking to parts of airplanes after a flight.

BALLOONING SPIDERS

Turning to Arthropods, McCook states that ballooning spiders have been found more than 200 miles from land and at elevations of more than 1000 feet. He has concluded from a study of distribution in the tropical regions that these spiders may have actually circumnavigated the globe on the wings of the wind. The known distribution of small flies in tropical areas likewise suggests that winds may have played an important part in carrying these minute, fragile insects.

BUOYANCY

It is evident that the duration of a drifting period is closely related to buoyancy. This applies not only to particles of dust, to small seeds and spores, but also to insects. A brief survey of the situation is sufficient to show that most of the insects drifting long distances in the air have a relatively high buoyancy. This is illustrated by a number of the larger butterflies, certain fragile Geometrid moths and the dragon flies. It will be noted in this connection that there are comparatively few records of the larger, heavy-bodied moths, such as the Bombycids and the Sphingids, being carried long distances, although the latter are strong flyers and occasionally turn up in unexpected places. The spread of the heavier armored insects, such as beetles, by the agency of winds is usually by relatively short stages, as in the case of the Colorado potato beetle and the cotton boll weevil, yet some of these insects are rather strong flyers and it is probably this factor which explains in considerable measure the notable collections of lady beetles or Coccinellids on mountain tops. The relative importance of buoyancy in this connection is suggested by the fact that very weak or minute forms, such as plume moths, midges and thrips, are known to drift long distances and here at least it would seem that air currents rather than the efforts of the insects themselves were the principal transporting agencies.

It is stated by Clark (1925, p. 105) that the larger the animal the smaller in proportion are the wings. He adds that in the mosquito for each pound of body weight there is a wing area of

4 square yards, 6 square feet and 105 square inches, whereas in a butterfly of average size each pound of body weight represents a wing area of 3 square yards, 8 square feet and 87 square inches. In the swallow this is reduced to only 4 square feet and 18 square inches and in the pigeon to 1 square foot and 14 square inches. He adds that not only do small birds have proportionately larger wings than bigger ones but they move them much more rapidly. He states that the wing beats of the common cabbage butterfly are at the rate of 540 strokes a minute, of Sphingid moths at the rate of 4320, of a wasp at the rate of 6600, of a honeybee at the rate of 11,400, of a housefly at the rate of 19,800. These figures may be true of the wing movement in purposive flight. It would seem reasonable, however, that buoyancy is proportional to the relative size of the wings, and if this be the case, insects should possess superior drifting powers and be more readily lifted to considerable heights by upward air currents.

VELOCITY OF INSECT FLIGHT

Investigations by Dr R. J. Tillyard showed that one of the larger dragon flies covered between 80 and 90 yards in three seconds, a rate of approximately 60 miles an hour (Clark, 1925, p. 122). The deer bot fly, *Cephenomyia phobifer* Clark, is said to fly with incredible swiftness, possibly 400 yards a second (Townsend 1926, p. 309; 1917, p. 101). Observations by Professor H. T. Fernald (1925, p. 638), indicate a velocity of 30 miles an hour for a dragon fly. Similar observations by Dr A. N. Caudell show a speed of 15 miles per hour for a grasshopper, *Camnula pellucida* Scudd. One should distinguish clearly between the flight powers of the insect and flight plus wind drift, the latter representing usually the rate of travel by a swarm.

INSECTS AT SEA

There are many records of larger insects appearing upon vessels at some distance from land and in not a few instances there are numbers of several species. A few of the more significant are given below.

The observations of F. Wood-Jones (1912, p. 308-9), indicate that dragon flies go to sea of their own accord and that they are not blown from shore. He states that in periods of absolute calm of long duration, *Pantala flavescens* may be seen hawking about over the sea 20 miles or more from the nearest land. This is entirely credible when it is recalled that dragon flies have

been known to approximate the speed of 60 miles an hour. Furthermore, he has observed numbers of this species almost daily in a journey through dead calms all the way from Singapore to Thursday island. He has seen them also at almost every point between Java Head and Cocos-Keeling islands, flying over the sea and giving no impression of being unfortunate storm-driven exiles. He adds that strong flying butterflies do the same, flying away from the land in an irresponsible way and that moths come nightly to a ship's light when she is lying 20 miles from shore. These statements agree closely with those of Commander Walker given elsewhere in relation to the monarch butterfly occurring somewhat commonly in the watery expanses of the South Pacific. There are records of several species of terrestrial insects alighting upon the surface of the water and again taking wing.

The widespread nature of insect flight or drift is also evidenced by Professor Wood-Jones (1912, p. 310) when he records the appearance on the Cocos-Keeling islands of the larvae of *Plusia chalyctes* Esp., on the first crop of tomatoes and peas raised from seed in that out-of-the-way part of the world, and this on islands where no specimens of the insect had been seen before, and yet infestation followed very shortly after a suitable foodplant appeared. A close parallel to this is found in the appearance of a caterpillar, a species of *Copitarsia*, a Noctuid, on a small patch of corn shortly after it was planted in the northern part of the desert of Atacama, Chili, in a locality where there was no vegetation nearer than 50 miles, though it subsequently developed that corn was grown on an irrigated area some 60 miles distant.

The especially interested reader may wish to refer to Muller (1871, p. 175-86) and to Hurd (1920, p. 94-98).

The Cocos-Keeling islands, mere bits of land in the Indian ocean, isolated by nearly 1000 miles of water, are off the usual trade routes and have very limited commercial activities. The fauna and flora therefore owe their origin largely to natural causes. It is interesting to note that Darwin in the early part of the last century (1882, p. 456) found 13 species of insects on this island, a minute elater, one *Gryllus*, a *Blatta*, a Hemipteron, two Homoptera, a *Chrysopa*, two ants, two Lepidoptera and two species of Diptera. The presence of such weak flying forms as *Chrysopa* and *Pterophorus*, both species unlikely to be carried by commercial agencies, is suggestive as to drifting possibilities.

Later Henry O. Forbes (1885, p. 30-31) observed a number of insects on these islands, mentioning in particular species of the

genera *Serica* and *Anomala* and stating that after a cyclone the surface of the water was observed densely strewn with the broken bodies of dragon flies. He also states that the large atlas moth, *Attacus atlas*, has become established in the islands.

More recently Professor Wood-Jones (1912, p. 312) records from these islands 33 species of Lepidoptera, 32 Hymenoptera and 11 species of Diptera, indicating these as presumably mostly wind-borne. Furthermore (p. 204-5) he observed the rather common appearance of dragon flies following northerly winds even of short duration and stated that these insects were unable to establish themselves upon the islands because of the scarcity of fresh water. Reference to a map of that part of the world suggests that Sumatra and the numerous islands surrounding it may be the breeding area for these dragon flies.

The appearance in the mid-Pacific on April 29th of a Noctuid moth, *Achaea melicerta* Cram., on board the "St George," as recorded by Mr Collenette (1925), in latitude 31° , 20 min. S., longitude 120° 29 min. W. and 450 miles from the nearest land (Ducie island), Henderson island being 525 miles and Pitcairn island 570 miles away, certainly indicates widespread wandering. The specimen was in good condition. This insect is recorded as having a very wide range throughout the eastern tropics, extending from the Persian gulf to the Marquesas, the larvae feeding on the castor oil plant.

A mourning-cloak, *Evanessa antiopa* Linn., was observed by Scudder 20 or 30 miles off the coast of North Carolina. Large swarms of the cabbage butterfly, *Pieris rapae* Linn., have been observed in the Baltic sea, some 10 to 30 miles from land, and individual specimens have been taken on an Atlantic steamer when more than 1000 miles from land. A number of other records of similar import could be cited.

Some miscellaneous data relating to Coleoptera, Hymenoptera, Diptera and Hemiptera are given by Hugh Scott (1926, p. 156-69), the insects either being observed on the beach or on the water at some distance from the land.

INSECTS IN THE DESERT

If insects are somewhat irresponsible, casual wanderers over the ocean, the same should be more or less true in deserts. This is indicated by the belief of Professor C. B. Williams, chief entomologist, Ministry of Agriculture, Cairo, Egypt, to the effect that the supply of painted lady butterflies for all Europe north of a line

through the middle of France and south Germany or Switzerland originates from African areas south of the Great Desert. In other words, there must be an extensive migration or drifting across miles of inhospitable land areas. He also finds mosquitoes, *Corixa*, small moths, house flies, and even May flies many miles in the desert (1926, p. 282), apparently blown in by the almost constant north wind in the country, though it appears to us quite possible that this is a drifting rather than, as suggested above, involuntary transportation. A recent communication from Edmund C. Jaeger of the department of zoology, Riverside Junior College, Riverside, Calif., states that he has been much interested in migrations of painted lady butterflies over the Colorado and Mohave deserts and marvelled at the powers of flight in this case against the prevailing air currents, adding that such flights occurred in 1919 and 1924. Here again there is a possibility that a not inconsiderable proportion of this movement is drifting rather than purposeful flight.

The appearance of a species of *Copitarsia*, a Noctuid, as a larva on a small patch of corn shortly after it was planted, in the northern part of the desert of Atacama, Chile, in a location where there was no vegetation nearer than 50 miles, constitutes another bit of evidence along this line.

Professor T. D. A. Cockerell states that during the summer of 1925 on the slopes back of Antofagasta, Chile, he found absolute desert without vegetation except for a single seedling of *Mesembryanthemum*, and yet he took a small Tineid moth (presumably a stem gall maker, *Gnorimoschema*, det. Busck) and a *Thysanuran*. At Mollendo, Peru, in extreme desert, he also found a few *Thysanura*, adding that these insects seemed to be able to live in very dry hot places better than any others, though he does not know what they found to eat under such conditions.

There is in Egypt a general belief that fleas are blown from the desert and data given by Chief Entomologist C. B. Williams (1925) indicates a marked local increase in the flea population following periods of dust-laden winds. This is suggestive, though not conclusive.

A feature of the desert is the locust invasion, according to Hingston (1925a, p. 286) writing of desert conditions in the vicinity of Bagdad. He records immense swarms passing overhead, adding that they are much influenced by aerial currents, the locusts near the ground sometimes moving in a different direction from those at some elevation.

INSECTS AND STORMS

Granting for the time being that there is an aerial insect population, there should occasionally be conditions which would result in forcing many into the water, and such a case seems to have been observed by Professor James G. Needham (1900, p. 19-28). He records the accumulation August 13, 1899, of enormous numbers of insects on a Lake Michigan beach at Lake Bluff, Ill. He states that there was a thunderstorm and gale two days previously and he infers that the insects might have been carried out over the lake by the high winds. It seems more probable that the thunderstorm and possibly the accompanying lower temperatures forced the insects into the water and that the large numbers he observed represented a somewhat normal air population over the lake. He found in the drift Orthoptera, Odonata, Lepidoptera, Coleoptera, Diptera, Hymenoptera, Hemiptera and Trichoptera. One liter of the drift material contained 2520 crickets (*Nemobius fasciatus* DeG.), 686 grasshoppers (*Melanoplus*), 85 Tettigidae, 75 dragon flies, 15 butterflies, 30 moths, 25 ground beetles, 75 of the smaller foraging Carabidae, 15 Scarabaeidae, 35 Coccinellidae, 21 wasps, 30 Hemiptera and a number of other insects. It is evident that it was a miscellaneous lot and their presence in the drift in such large numbers could hardly be explained as the result of unusual migratory impulses. The great predominance of crickets is due probably to a general flight of these insects, since they were recorded as appearing in immense numbers the preceding day at lights in Rockport, Ill., some 70 miles distant. The drift line was perhaps 50 and possibly 100 miles long. The species were regarded by Professor Needham as nearly all dominant ones in their respective groups and the fittest of their kind.

It is possible that less conspicuous forms were also involved, since earlier observations by Dr E. A. Schwarz (1890, p. 208) showed that representatives of all orders came to a raft passing through Lake Sinclair during the summer of 1874 at a time when the raft was at least five miles from the nearest shore. He has found large accumulations of insects on the sandy beaches of our Great Lakes when there was a gentle though steady breeze for at least several hours toward the shore, nocturnals as well as diurnals being represented, including many of the most delicate species, such as gall midges (*Itonididae*), fungus and other gnats (*Sciaridae* and *Mycetophilidae*). He states that these small forms were washed ashore unharmed, whereas the larger, more robust species were apparently much less capable of enduring immersion.

Kenneth J. Hayward records (1925, p. 147-49) a remarkable migration near Villa Ana, province of Santa Fé, Argentine Republic, South America, on March 27th. A number of species of butterflies and many dragon flies of several species were observed, the main flight lasting less than 11 minutes and thereafter a continuous stream of stragglers passing for some minutes. The record stated that many hundreds of thousands of insects were involved, flying from just above the ground level to over 42 feet. The prevailing wind was S.S.E. freshening, the sky heavily overcast and the flight northward. In a letter Mr Hayward mentions a storm raging over the corrientine side of the Parana. The above, taken in connection with Hudson's record and observation on the behavior of dragon flies just before the appearance of the cool *pampero*, suggests the possibility of some such aerial disturbance at no great distance, driving the insects before it or toward the ground and producing conditions which resulted in a local migration. On April 2d the same author records in the July issue of the Entomologist, page 169, an all-day butterfly migration at Guillermina, the barometer falling slightly and a fresh N.N.W. wind blowing, the insects moving toward the north. On April 12th another migratory flight was recorded at Villa Ana, the insects flying fast, at a height of some 50 feet or more and with a south fresh wind. The sky had been overcast for four days with intermittent rainstorms and the insects were observed at 4.30 p. m. at a time when the air had suddenly cooled considerably. Here again we have conditions very similar to those recorded by Hudson.

On April 15th there was another migratory flight during clear sunny weather, the wind northwest, the insects moving north. There is no record of barometric pressure. The minimum temperature the preceding night was 55.4° F. This latter raises a question as to whether the sudden cooling of the air indicated by the above minimum may not have driven the insects nearer the surface and produced this apparent migration.

Another case probably illustrating the influence of storms upon insect life is cited by Mr Hayward (1925, p. 147-49) of Villa Ana, Argentine Republic, South America. He states that there had been a heavy thunderstorm on the preceding night far to the eastward. The migratory flight commenced at approximately 4.40 o'clock the following afternoon and ceased at a little after 5 o'clock. It consisted of a mass of butterflies representing nine different species, some common, moving from south to north and accompanied by many dragon flies. Mr Hayward was of the opinion that the flight

included specimens of practically all the butterflies then flying in the open country of that district, this latter suggesting some physical explanation, the most probable being the nearby storm, particularly if this be considered in connection with earlier records of the same character.

The effect of storms and the possible source of some of these large assemblages of insects are suggested by Gätke's account, as rendered by Tutt, of the appearance of millions of *Libellula quadrimaculata* in Heligoland. Countless swarms were reported as making their appearance suddenly during the calm, sultry hours preceding a thunderstorm. The insects did not arrive in swarms or companies, but solitary individuals or scattered groups congregated in a vast throng. The assembling individuals or groups must have followed each other in very rapid succession, for in a short time the face of the cliff, all the buildings, hedges and dry twigs on the island were covered with them. The insects disappeared as suddenly as they appeared. They did not remain on the island, nor did one find them lying about dead after the thunderstorm (Tutt, 1899, p. 182). It is quite possible that these remarkable assemblages are due to the normal aerial insect population being driven from the air by the impending storm. It may be simply a variant of the phenomenon recorded by Hudson in relation to dragon flies and the *pampero* in the Argentine.

Tutt, on the above cited page, records local swarms of this same dragon fly appearing a short time before a thunderstorm in several German localities and also mentions great numbers of this same insect, which he associates with flood conditions, in the river Soale.

LIGHTHOUSE AND LIGHTSHIP DATA

In connection with the distribution of the European corn borer, *Pyrausta nubilalis* Hubn., noted above, there were some studies made under the direction of D. J. Caffrey of the European Corn Borer Laboratory, Arlington, Mass., at lighthouses along Lake Erie, namely, Point Gratiot, Dunkirk, N. Y., Conneaut, Ashtabula, Fairport and Huron, Ohio. During the season of 1922 the observations were carried on only during periods when the winds were blowing across Lake Erie from the direction of the Canadian shore. Hence the presumption was that adults probably crossed the lake. H. N. Bartley, in connection with these studies, notes: "At times when the wind was blowing hard, say about 25 or 30 miles per hour, the observer noted several small moths being blown in from the lake past the rays of light (from the lighthouses), but these moths were unable to stop at the light. Attempts were

made to capture them as they passed close to the light, but with no success." An examination of the material collected by Mr Ellis of the corn borer laboratory showed that *E ver g e s t i s t r a m i n a l i s* Hubn., predominated, although there were also various Geometrids, Tineids, Noctuids, Pyralids, especially certain species of *Phlyctaenia* and a number of *Gnorrimoschemas* (which breed in goldenrod) in the collections.

Recently we sent a questionnaire through the Federal Lighthouse Service to 20 of the lighthouse keepers on the Great Lakes and along the northeastern coast of the United States to see if they noticed the habitual coming of insects to the lights. Invariably they stated that different species came to the lights commonly in midsummer and this was true even of lighthouses seven to 28 miles from the nearest land or vegetation and with the lights at elevations up to 128 feet above the surface. This would indicate that insects commonly drift in the air at an appreciable height above the surface of the water.

The habitual occurrence of insects some distance from the land is also well shown by the observations of William Eagle Clarke (1903, p. 289-90) on the Kentish Knock Lightship for a period of 31 days, namely, from September 17th to October 18th. This lightship is situated in the North sea, northeast off the mouth of the Thames, 21 miles from the nearest points of the land, which are Margate and the Naze (Essex), and lie respectively southwest and west and northwest from the vessel. The nearest points to the continent are the northern coast of France and the Belgian coast which are distant from 48 to 56 miles south-southeast and southeast from the lightship. The following is Mr Clarke's record:

On September 23d, in addition to the butterflies, there came a number of *Plusia gamma* Linn. and hundreds of small Trichopterous insects, which my friend Mr Kenneth J. Morton has determined as *Limnophilus griseus* Linn., and *L. affinis* Curtis. The presence of these latter is also strongly suggestive of migration from the continent, for it is scarcely possible that such delicate insects could have flown for at least 21 miles against the gentle breezes which prevailed, as they must have done if they came from the southeast coast of England. Two specimens of the fly *Helophilus trivittatus* Fabr. and one of *Sphaerophoria* (named by my colleague Mr P. H. Grimshaw) appeared at the same time, and many other species, including a Tortrix, a Plume moth, and a Hemipterous insect, which I have been unable to determine. On the morning of September 28th I took fine fresh specimens of *Ennomos alniaria* Linn. (male) and *Apamea testacea* Hubn. at rest on the lee side of the deck house.

The rather common occurrence of insects some distance from land and available breeding places is shown by the studies of S. C. Ball (1918, p. 193-212) on the Rebecca Shoal Light Station located in 12 feet of water upon Rebecca shoal, a small and entirely submerged part of the Florida reef 12 miles east of the Dry Tortugas and 48 miles west of Key West. The nearest point from the mainland of Florida is Cape Sable, 105 miles northeast. Havana lies 95 miles to the south on the Cuban coast while Cape San Antonio at the western end of Cuba bears southwest from Rebecca shoal at a distance of 230 miles. Cardenas bay lies 135 miles to the southeast. Between Rebecca shoal and Key West there are several keys, the Marquesas group being the largest and nearest to Rebecca shoal — 24 miles east — and being largely covered with mangrove swamps which furnished breeding places for myriads of mosquitoes. Insects reaching Rebecca Shoal Light Station by flight alone must cover either 12 miles from Tortugas on the west or 24 miles from Marquesas on the east, or at least 105 miles from the mainland on the east and north or 90 miles or more from Cuba. There was apparently no opportunity for insects to breed at Rebecca Light Shoal. The author finds that large numbers of mosquitoes and houseflies were carried by northerly and southerly winds to Rebecca Shoal Light Station and the Tortugas points from Florida and Cuba, each about a hundred miles distant. Easterly winds bring a few of these insects as well as smaller numbers of glowflies, horseflies and gnats from islands on the Florida reef. Occasionally Odonata, Neuroptera and Lepidoptera are carried by winds to these parts of the reef. It is interesting to note that such comparatively inefficient flyers as a lace-wing, *Chrysopa*, a damsel fly, and fragile gnats were taken on this shoal as well as stronger flying insects such as Tabanids, blowflies and even dragon flies. The appearance of these insects in the main at least, coincided with favorable, mostly moderate winds, suggesting drift rather than purposive flight.

MOUNTAIN AND GLACIER DATA

Admitting that lakes may serve as traps for insects under certain conditions, and there is no gainsaying this, it would follow that patches of snow or ice, such as snowbanks or glaciers, would also capture many insects, partly as a result of the down currents they induce and partly because the lowering temperature of the higher altitude rapidly chills the insects and prevents their escape. It is easy to note this in the northern latitudes whenever there are small

patches of snow with moderately warm weather. The effect is emphasized if there be rapid melting of the snow and considerable running water, since this latter tends to bring the insects together in small depressions. It is well known that insects are sometimes found in extremely large numbers on glaciers, undoubtedly being carried to a considerable elevation by rising air currents and then dropped over the cooler ice. It has generally been assumed that insects found in such places came from nearby localities, very likely being carried up the mountainside. This is undoubtedly true to some extent, though it probably does not represent the entire truth. The occurrence of Coccinellids in the crater of Vesuvius (Leman, 1925, p. 143) near warm lava and hot vents is probably due to up-currents carrying the insects to the summit and their settling in the crater — a casual drift rather than purposive flight.

Major R. W. G. Hingston in his account of Animal Life at High Altitudes (1925, p. 337-47) describes the behavior of insects at 17,000 and 18,000 feet and records the occurrence of bees, moths and butterflies at 21,000 feet elevation on Mount Everest.

We have called attention elsewhere to the fact that insects probably drift considerable distances with the wind and if this is true we should expect a suggestion of such movements in collections on high mountains, particularly if the air currents are able to carry insects hundreds of miles. A number of entomologists have collected a considerable number of species on or near the summit of Mount Washington, N. H. Attention has been concentrated upon rare and presumably northern forms. With the possibility of wind spread in mind we have scrutinized these records, selected a number of species which were presumably southern in habitat, and after submitting these tentative lists to such coleopterists as Blatchley, Leng, Van Dyke and Wickham, we find them in substantial agreement as to the southern habitat of *Enochrus consors* Lec., *Oxyporus bicolor* Fauv., *Boletobius dimidiatus* Er., *Eros sculptilis* Say and *Longitarsus turbatus* Horn, all taken during the warmer months of the year upon Mount Washington and none with a recorded habitat north of New Jersey. It seems quite possible, in view of what has been presented above, that these insects may have been carried long distances by favorable winds. Furthermore, it seems quite within possibilities that the enormous numbers of certain lady beetles or Coccinellids found upon mountains are carried there by favorable winds, since their dependence upon ephemeral aphids for sustenance places a premium upon a free-flying habit.

INSECT DRIFT IN THE EXTREME NORTH

There is abundant evidence to indicate northerly insect drift in the northern hemisphere and our general knowledge of wind currents would suggest that under certain conditions these winds would extend to the extreme north, presumably carrying their insect drift. The preceding data in relation to mountain and glacial drift suggest the probability of insects dropping on islands in the far north in the same way that they collect upon glaciers in lower latitudes where altitude produces arctic or nearly arctic conditions. A paper by C. S. Elton (1925, p. 289-99) on the Dispersal of Insects to Spitzbergen, a group of islands lying well to the north of the Arctic Circle, is most interesting. North-East Land lies in latitude 80° , is the second largest island of the group, is about the same size as Wales and the author states is almost entirely covered by a thick ice cap which rises to some 2300 feet above sea level. There are patches of barren rocky land around the coast, which possess an exceedingly scanty fauna. He records that several parties in August 1924 found a large black aphid identified as *Dilachnus piceae* Panz., and a flower fly, *Syrphus ribesii* Linn., on various dates in different localities and in such numbers as to suggest that "hundreds of thousands or even millions" of these insects had been blown in a broad belt over the island. The fact that there are no trees proves that these insects must have come from some other country and it is surmised that they may have come from the Kola peninsula, a distance of over 800 miles in a straight line. This idea was confirmed by the fact that weather conditions during this period, August 6th, 7th and 8th, were favorable for strong south and southeast winds blowing from Europe over Spitzbergen and more especially North-East Land. It is suggested that this condition coincided with an extraordinary aphid infestation far to the south.

The above duplicates to a very large degree the conditions such as occur when large numbers of insects are found upon a glacier, except that the icy surface in this instance is nearly a thousand miles from the presumed source of supply. A drift over this distance is by no means impossible, judging from abundant data in relation to other insects in various parts of the world. The insect drift in these high latitudes would naturally be much less than in more temperate regions and here as in some other cases it is believed that this one record indicates a condition much more general than many have suspected. There are reasons for believing that many sections of the arctic areas may be sown from time to time with various insects, the species in most cases being extremely abundant one or two thousand miles south.

INSECT DRIFT ALONG THE LITTORAL

A very striking instance of this character is recorded by Professor Needham and discussed briefly under insects and storms. Following up this work, Miss Snow (1902, p. 855-64) made a study of insect drift of Lake Michigan between April 14th and May 31st, collecting 114 species, 51 of which were identified. The 75 species of Coleoptera were divided as follows: Carabidae 33, Scarabaeidae 10, Chrysomelidae 9, Coccinellidae 7 and other families in small numbers. On May 27th she found the Colorado potato beetle, *Leptinotarsa decemlineata* Say, so abundant that the beach at Cheltenham was nearly covered with beetles dead, dying or active, very few remaining alive May 31st. This plainly indicates that many had flown or drifted well out over the lake. June beetles were also very abundant at about the same time. Undoubtedly some attempted to cross the water and became exhausted. The downward currents of air over streams and lakes are well known and doubtless assist in bringing insects to the surface.

Professor Herbert Osborn, Columbus, Ohio, records a somewhat similar condition along the shores of Lake Erie, stating that the insect drift is quite varied, a large majority being species that occur within a few miles on the mainland. He states that insect drift occurs very frequently, since southerly winds were very commonly followed by westerly and northerly winds which would bring the drift ashore.

The same condition has been observed on the British coasts by the veteran entomologist, Robert McLachlan (1884, p. 234). He records swarms of *Coccinella* as occurring occasionally upon the British coasts and adds that masses of dead aphids sometimes formed tide refuse along the southern shore.

Early in the morning of August 15, 1926, numerous *Hippodamia convergens* Guer., and one *Coccinella novemnotata* Herbst. were taken on the beach at Greenport, L. I., there having been a rather strong northerly wind for some hours and the insects coming in with the drift. It is very probable that they crossed Long Island sound, some ten miles wide at that point. Hundreds of the *Hippodamia* could have been taken from the beach drift.

The following has a direct bearing upon insect drift since it indicates the crossing of somewhat wide stretches of water by a species ordinarily associated with the desert. Dr H. H. Severin in October 1925 stated that there were enormous migratory flights the past season of the beet leaf hopper, *Eutettix tenella* Baker.

The insects, evidently migrating from the San Joaquin valley, must have flown across either San Pablo bay or Suisun bay, a distance of approximately ten miles and three miles respectively. Meteorological changes might easily have driven these insects to the surface of the water and resulted in beach drift, as recorded above for other localities.

DATA FROM KRAKATOA AND OTHER ISLANDS

The terrible eruption of August 1883 devastated this entire group of islands, judging from available records. Incidentally, it may be stated that dust discharged during this eruption rose to an estimated height of 17 miles and within six months was diffused over the whole surface of the earth between 30° north and 45° south latitude, eventually being carried north and south over North America, South America, Europe, Asia, South Africa and Australia. This alone gives some idea of the sustaining powers of air currents.

Dr K. W. Dammerman (1922, p. 61-112) states that the three islands remaining after the eruption were overlaid by hot ashes, approximately 90 to 180 feet thick. It does not seem possible that anything living could escape under such conditions, particularly as the adjacent island of Sebesy, some seven miles distant, was partly and possibly completely devastated. It seems reasonable to believe that both plant and animal life were well nigh entirely destroyed on the Krakatoa group and that whatever may be found there at the present time represents a reestablished flora and fauna. Doctor Dammerman in the above-mentioned papers gives some extremely interesting data relating to the insect fauna, particularly when it is remembered that this group is approximately 20 miles from Java and nearly as far from Sumatra, although intervening islands to the northeast afford stepping stones, as it were, to facilitate the passage of both plants and animals. The nearest of these islands, as stated above, is Sebesy and that for a time was in a partly or completely devastated condition.

The following tabulation shows the number of species of the more important orders found upon this group of islands in 1908.

	Krakatoa	Verlaten	Sebesy
Hymenoptera.....	28	3	9
Lepidoptera.....	2	.....	.....
Diptera.....	32	11	12
Odonata.....	1	.....	1
Thysanura.....	1	.....	.....
	<hr/> 64 <hr/>	<hr/> 14 <hr/>	<hr/> 22 <hr/>

So much is dependent upon opportunities for collecting that too much relative importance should not be attached to these figures. It is perhaps sufficient to call attention to the fact that a number of the more important groups are represented and that the number of species is roughly proportional to the land areas.

Doctor Dammerman also gives lists of collections in later years from two of the Krakatoa group and the island of Sebesy, the latter for comparative purposes.

Species Taken On Two of the Krakatoa Group and the Island of Sebesy

	Krakatoa	Verlaten	Sebesy
Danaida.....	4	2	5
Blattoidea.....	6	4	6
Mantoidea.....	1	.....	1
Phasmoidea.....	.....	.....	1
Gryllacridae.....	1	1	5
Gryllidae.....	5	3	11
Gryllotalpidae.....	.....	1	1
Locustidae.....	6	4	6
Acrididae.....	7	7	11
Thysanoptera.....	10	4	13
Psyllidae.....	.....	.....	2
Aphididae.....	1	1	1
Coccidae.....	5	5	3
	<hr/>	<hr/>	<hr/>
	46	32	66
	<hr/>	<hr/>	<hr/>

Here again too much importance should not be attached to the relative number of species occurring upon the three islands, although it should be noted that there is not a very wide discrepancy, the largest number being found upon Sebesy, which is recorded as only partly though possibly completely devastated during the late eruption. It is furthermore a larger island and distinctly nearer Sumatra than any of the Krakatoa group. The species recorded in 1921 from Krakatoa and Sebesy total 441 and 474, respectively, indicating no great discrepancy in the insect fauna. The data would seem to sustain the belief that insects drift rather freely in the air. Otherwise there could hardly be such a general restoration of the insect fauna. Furthermore, Doctor Dammerman calculates that the winged animals on Krakatoa, Lost island and Sebesy represent 81, 83 and 79 per cent of the total fauna, respectively, the wingless forms accounting for the remainder. This alone suggests the importance of drifting or flight in restoring the fauna.

Doctor Dammerman calls attention to an exceedingly interesting development on Verlaten island. In May 1908 there was a lagoon still connected with the ocean, which later became separated from the sea and is now a brackish water lake surrounded by a swamp and affording suitable conditions for six species of Coleoptera, three of Diptera, three of Heteroptera and five of Odonata, all presumably comparatively recent arrivals. A scrutiny of the species recorded from the Krakatoa group in 1908, likewise published by Doctor Dammerman, does not suggest that it was the strong-flying species alone which were able to make their way to these comparatively isolated islands. Species of *Tetramorium*, *Monomorium*, *Campopnotus*, *Ichneumon*, *Hemiteles* and *Xanthopimpla* in the Hymenoptera, do not suggest more than very ordinary flying ability, although the possibility that the ants drifted with logs should not be overlooked. Limited flying powers appear to be true in the Diptera for such species as *Sciara*, *Dicranomyia*, *Baccha*, *Lonchaea* and *Agromyza*, some of which may have utilized rafts for transportation across the water. The excellent representation of Thysanoptera found in later years is also most suggestive of insects drifting with the wind, rather than disseminating themselves through conscious flight. In this respect these data bring to mind the capture of delicate, presumably poor-flying insects at the Kentish Knock Lightship in the North sea and at the Rebecca Shoal Light Station off the coast of Florida. There is the possibility that the rather frequent passage of vessels through the straits may have assisted materially in restocking these islands with both plants and animals, even then one can hardly avoid the conclusion that winds have played an important part in carrying winged insects to the Krakatoa group.

The record of galls collected by Dr W. Docters Van Leeuwen, (1920, p. 57-82), on the islands of Krakatoa and Verlaten is extremely interesting, in view of the above outlined history of the group. He refers to the finding of galls of *Eriophyes pauropas* Nal. in 1896, again in 1905 and 1906 and lists and describes 24 gall producers divided as follows: 13 gall mites, seven gall midges, three Psyllids and one aphid. While there is a remote possibility of a few gall mites being carried by wind-blown infested leaves, it seems more reasonable to think that most if not all of these tiny forms were swept across by favorable winds. There is even less chance of gall midges being carried within the galls and in this case the probabilities favor transportation by air currents. The same is true of the Psyllids and the plant louse. The mites certainly can

not fly. They are considerably lighter than fine particles of earth which we know are carried enormous distances. Records in relation to other insects indicate a probability that these weak-flying forms easily drift the approximately 20 miles separating this group from Java with its teeming insect population.

Below we are giving a comparative tabulation by T. Bainbrigge Fletcher, imperial entomologist of the government of India, which appeared in the *Bulletin of Entomological Research*, 16:178, 1925.

	1908	1921
Apterygota.....	1	2
Odonata.....	1	4
Isoptera.....	2	2
Orthoptera.....	14	27
Thysanoptera.....	0	10
Rhynchota.....	15	74
Neuroptera.....	1	3
Coleoptera.....	23	115
Hymenoptera.....	51	66
Lepidoptera.....	10	84
Diptera.....	32	54
Total insects.....	150	441
Total animals.....	196	573

The above figures are eloquent on developments since the devastation of 1883.

Tutt (1900b, p. 14-16) summarizes some very interesting movements of Lepidoptera over Heligoland, stating that huge swarms of various insects, such as *Hybernia defoliaria*, *H. aurantiaria*, *Ennomos angularia*, *Plusia gamma*, *Psilura monacha*, and other Lepidoptera have been observed in an east to west flight, following the same course and in association with migratory birds or following this course under conditions known to be acceptable to migratory birds, sweeping across the island and even being found in immense swarms on the east coast of England, under conditions which he believes could be explained only as a migratory flight. In the case of *Plusia gamma* these flights are so enormous in some cases as to suggest the flakes of a dense snowstorm. These migrations, more probably driftings with favorable winds, are supposed to originate in Schleswig-Holstein, the distance to the English coast being 400 miles. The swarms of Geometrids mentioned above are duplicated to some extent at least in America by the immense flights of our native

Ennomos subsignarius Hubn. and *Erannis tiliaria* Harris, though under our conditions it has usually been impossible to establish the distance covered by these flights with any degree of precision.

Tutt (1900a, p. 254) states that there are many records of *Pieris rapae* Linn. and *P. brassicae* Linn. crossing the English channel to Dover, and refers to a record of a large flight July 5, 1846, the insects being so numerous as to obscure the sun completely, the decks being strewn with the insects. The weather was calm and sunny, though in an hour or two after the butterflies reached the land the wind blew "great guns" from whence the butterflies came. It is possible that here also the wind and adjacent storms may have materially concentrated the normal aerial population. Tutt also mentions in this connection a number of records by various observers of butterflies settling for a short time upon the sea and rising with apparent ease.

HAWAIIAN INSECT FAUNA SUGGESTS WIND SPREAD

There are some peculiarities in the endemic Hawaiian insect fauna which strongly suggest wind spread as the principal natural means of stocking the islands. Whole groups of insects are missing and the orders present are represented by only a few families which could have come by flight or by air or ocean currents. The Lamellicorns are represented by a single genus composed of a few allied species of Lucanidae and these are confined to the island of Kauai. The Scarabaeidae, the grubs of which live in the soil and all of the Phytophaga, the larvae of which occur on leaves, are likewise not represented. Both groups have limited powers of flight and are too heavy to drift far with winds. The brilliant tiger beetles, Cicindelidae, are also absent (Muir, 1921, p. 161).

It is estimated (Swezey, 1921, p. 172-74) that only 17 of the 43 Coleopterous families are represented in the native Hawaiian fauna. It is noteworthy that such Neuropterous families as the Trichoptera, Perlidae, Ephemeridae, Mantispidae and Panorpidae are entirely absent, and such important Dipterous families as the Culicidae, Tabanidae, Syrphidae, Asilidae, Muscidae, Dexiidae and Tachinidae are not represented in the endemic fauna. Among the Orthoptera only about half are endemic, there being no native stick insects or Mantids and no true grasshoppers.

The following presents some interesting generalizations upon the problem and is especially valuable because it represents the opinion of one well acquainted with local conditions:

Though the distance between the islands and other lands is so great, yet we know that, like the migrant birds of Alaska that visit the islands, certain insects of migratory habits like the large dragon flies, the butterflies, *Pyrameis cardui* and *huntera*, the small moth, *Nomophila noctuella*, and others have been able to reach the islands, and probably still do arrive from time to time, so we need not feel any difficulty in believing that at some period, a lesser-sized dragon fly (*Agrion*) or an ant-lion (*Formicaleo*) — insects which could only have arrived on their wings — have been able to traverse a similar expanse of ocean by some rare chance. * * * Over what distance minute and delicate winged insects can be wind-borne is not known, but probably under favorable circumstances it is very great. * * * High and steady currents of air are probably most efficient. A number of the existing species of moths are of powerful flight and are partial to wind-swept country, and it is a familiar sight to see these, when disturbed, allow themselves to be carried far away on the strong wind. Given this habit of allowing themselves to be thus carried, small moths might even be able to pass over greater distances than heavier-bodied species. In the inter-island distribution of species whirlwinds may have occasionally assisted. * * * These whirlwinds have been seen to carry up thick columns of dust to an elevation of over 2000 feet and we have once or twice observed them to originate at this elevation in the mountains. Small creatures carried up in this way and meeting high currents of air might be borne for great distances before alighting. (Perkins, 1913, p. xlvii-xlviii).

CAUSES OF INSECT SWARMS

The causes resulting in large swarms of insects should be briefly considered since these ordinarily are the starting points of dispersal. The nearly simultaneous development of millions of mosquitoes, midges, caddice flies, black flies and butterflies within a restricted area accounts for many swarms. The winged insects under such conditions undoubtedly find themselves too close to each other for comfort and there is a general tendency to move in the direction of greater freedom which, other things being equal, would mean a uniform spread in all directions from the original source of the swarm. Practically speaking, other conditions such as swift or cold air currents, light, contour and vegetation undoubtedly have a marked influence in determining the direction of movement. It might easily occur and presumably frequently happens that in the case of such insects as grasshoppers a uniform movement from one side of an enormous swarm, particularly if this movement were aided rather than hindered by favorable winds, might easily result in the speedy development of a general flight or drift in that direction — a mere mechanical reaction to local conditions which may be subsequently greatly modified by the abundance or scarcity of foodplants.

The records of Professor Needham in regard to lake drift and much other less specific data clearly establish the fact that under certain conditions air currents or changes in temperature may either force down large numbers of insects or produce conditions which result in considerably greater concentration than is ordinarily found in the air, such as forcing numbers down to the water surface and causing them to drift to the beach. The influence of air currents may be compared in a general way at least with the effect of water currents in concentrating débris. A rapid stream flowing into a still body of water carries considerable débris which tends to collect at the point where the rapid waters are checked. Somewhat the same condition appears to prevail in the case of winds moving into areas of considerable calm, especially if there is a marked difference in temperature. It would seem, with the following in mind, that the concentration of dragon flies observed by Hudson just in advance of the cold *pampero* of Patagonia is more probably explained by the rapid air currents sweeping across the stiller air and bringing about a temporary concentration of the insects at the point of contact, rather than by the wind having carried the dragon flies for hundreds of miles, though the latter is a possibility. The *pampero* is an extreme case. Winds are continually driving across the stiller air and if such conditions tend to produce concentration of the normal aerial insect population, which seems possible, even probable, then many of the minor assemblages of insects, even though along well-recognized bird air ways, may be in reality the normal result of an unsuspected condensation and the observed flight may represent the natural tendency of the insects to spread or disperse from such congested areas. The result would be movements along the same general lines because practically all the insects would be subjected to the same influences. In other words, the movement would be mechanical rather than purposive and largely along the lines of least resistance, unless there was some factor tending to modify flight and even this would presumably affect most insects in the same way. The mere fact that such movements occur along somewhat definite lines would suggest, if the foregoing explanation be accepted, that these lines coincided with conditions which were unusually favorable to the concentration of the insect aerial population and its subsequent dispersal. The swarms of hovering gnats in the lee of a tree or telegraph pole are typical of a mechanical response to even very light air currents. The somewhat general occurrence of local movements in such directions are at best only suggestive of migration such as is known of many birds.

SMALL INSECTS AND WINDS

It is evident that opportunities for purposive distribution without the aid of air currents are very restricted in the case of the smaller, weaker species.

The late Professor F. M. Webster (1902, p. 795-801) called attention to several instances where the delicate Hessian fly, *Phytophaga destructor* Say, was carried by prevailing winds into uninfested fields, stated that infestation by San José scale, *Aspidiotus perniciosus* Comst., is much more rapid from west to east with the prevailing winds and from a valley up a slope, the usual path of gentle air currents, and, most interesting of all, recorded somewhat habitual drifting of buffalo gnats, *Simulium*, some 20 miles from all possible breeding places and their attacking domestic animals in swarms. He quotes Professor Sajö to the effect that aphids creep to the crowns of plants in the sultry hours preceding a thunder storm and drop themselves at the proper moment into the violent currents which presumably carry them great distances.

The drifting of small insects with the wind is strongly suggested by the record of H. B. Johnston (1925, p. 132-33) that *Heliothrips indicus* Bagn., appeared October 15, 1924, at Khartoum, Sudan, Africa in large numbers, all kinds of vegetation being covered, following two or three days of a "fairly strong northerly wind." He states that cotton some 100 miles to the north had been heavily infested by thrips during the previous month and suggests as "highly probable" that the insects may have originated in such fields and drifted south.

The somewhat common occurrence of swarms of thrips is recorded in the case of the onion thrips, *Thrips tabaci* Lindm., by Professor H. T. Fernald (1925), who states that these insects during July are so common in portions of the Connecticut valley in the early evening as to make it somewhat unpleasant riding. The very general infestation of pear orchards by pear thrips, *Taeniothrips inconsequens* Uzel, suggests that this species also must have very similar habits.

It is well known that plant lice or aphids appear in swarms at certain seasons of the year and presumably drift long distances with the wind. In most cases these movements are correlated with migration from one food plant to another, overcrowding presumably being responsible for the primary stimulus. It is not easy to ascertain the distance covered by such swarms, although it is presumably considerable in many cases. Dr W. E. Britton (1919, p. 203)

records such a swarming of *Calaphis betulaecolens* Fitch throughout the city of New Haven and presumably originating in gray birches three or four miles from the center of the city. Dr A. C. Baker of the United States Bureau of Entomology has called our attention to the recorded swarming of the green bug, *Toxoptera graminum*, over northern Italy in 1852. He also states that Börner (1922, p. 27-35) secured evidence satisfactory to himself that aphids were carried 39 miles by the wind, a very moderate distance it appeared to us.

The fragile gnats taken by Doctor Ball on Rebecca shoal and mentioned above should be noted in this connection.

A remarkable abundance of caddis flies and midges (Chironomids) over a somewhat wide stretch of water is recorded by Dr W. L. McAtee (1915, p. 694-95) during the crossing of Currituck sound, N. C.; a distance of six miles, during which the insects were so numerous over the water that vision was perceptibly restricted and one was constantly annoyed by the impacts of the insects against the face. The same conditions were noted on a small steamer, the "Comet," which had come from many miles down the sound during the night. The midges were identified as *Chironomus halteralis* Coq., *C. modestus* Say, and *Tanytarsus* sp., all small and comparatively weak flyers. The caddis flies were determined as *Oecetina incerta* Walk., and *Oxyethira dorsalis* Banks.

The observations of Dr T. Bainbrigge Fletcher, Imperial Entomologist, India (1910, p. 321) respecting the wide distribution in the African, Indian and Australian regions of such weak flying species as Pyralids and Pterophorids are most suggestive in this connection.

The sugar beet root louse, *Pemphigus betae* Doane, winters upon certain poplars, spreading therefrom to the beet fields. A. C. Maxson of the Great Western Sugar Company (1918, p. 235) states that at Greeley, Colo., host trees are extremely rare, not one being found in the eastern section, which is at least 125 miles from the mountains and about 80 miles from the nearest known host trees. A careful study of conditions indicates a rather close connection between host trees and infestation, although the insects also winter as root lice in the soil of old beet fields. The more severe infestations appear to be correlated with the abundance of host trees, and in view of the fact that the prevailing winds of northern Colorado are westerly, it was held by Mr Maxson as not "unreasonable that these insects might easily be carried from the mountains many miles out upon the prairies by these winds."

The finding of aphids on the snow of North-East Land, 80° north, Spitzbergen islands, detailed elsewhere, is conclusive proof of extended drift by small insects of presumably very restricted powers of flight.

DIRECTION AND RATE OF SPREAD

It may be necessary to revise somewhat our opinions respecting the distribution of insects. The records, so far as this country is concerned, are too fragmentary in many cases to permit more than a suggestion along these lines. Enough data have been assembled to raise a serious question respecting some of the records representing actual distribution. It must be admitted that certain species drift or make their way far beyond their normal habitat. This process is unquestionably going on and is likely to continue.

The normal trend or spread varies somewhat, presumably, in different parts of the country, although for the United States as a whole it may be concluded that spread from west to east is relatively easy. This is supported by the gradual and somewhat rapid progress made by the Colorado potato beetle, *Leptinotarsa decimlineata* Say, from Colorado to the Atlantic coast, working east at the rate of about 80 miles a year. The spread was by no means especially rapid and certainly was not comparable with the drifting or flight of millions of cotton moths from the south to the north, yet this insect was found in immense numbers upon a lake shore beach as recorded above, indicating that the beetles fly readily and presumably remain in the air for a reasonable time. It is possible that the heavier insects, such as the Colorado potato beetle and the Mexican bean beetle, the latter spreading northeasterly at the rate of 150 miles a year, ordinarily do not allow themselves to be carried to such elevations as do the relatively lighter and presumably better-flying moths and Diptera. The annual spread for these two beetles is in excess of the recorded drift, for two seasons, some 50 miles a year, of the European apple and thorn skeletonizer.

There is another factor which should be taken into consideration in connection with wind spread, namely, the great dispersive powers of the winds as well as their carrying capacity. Only about one-fourth of the balloons liberated in 1923 continued in the direction they started. Even a very little dispersion in the course of a drift 25 to 50 miles would amount to a most considerable scattering and this would be much greater in the case of longer drifts or flight. This dispersive action of the wind undoubtedly prevents insect colonization in many instances unless very large numbers take to the air at the same time, a condition hardly likely to obtain except

when there is a very heavy infestation, as in the case of the cotton worm of the South.

The easterly drift mentioned above is only one of the favored lines of spread. There is abundant evidence to show that in the United States there is a marked northeasterly drift which at times may become northerly, and under exceptional circumstances possibly northwesterly. There appears to be, in the northeastern United States at least, a relatively very small westerly drift.

An understanding of these tendencies among insects after making due allowance for probabilities and possibilities, the latter by no means easy to estimate, permits the formulation of possibilities in a general way so far as preventing the spread of introduced insects is concerned. It is, for example, useless to attempt to do more than retard spread of free-flying species in the direction of the prevailing air currents. Conversely, it may be possible to check spread rather effectively against prevailing winds at the time insects are in flight or in a stage when they may be carried by air currents.

The occurrence of southern, or for that matter, northern insects outside their normal habitat may be suggestive as to prevailing lines of drift. There is great need of detailed data respecting the occurrence of many species in different sections of the country. Such records should distinguish between the occasional visitor, the annual migrant and the species able to maintain itself indefinitely in the different areas. It is suggested that in the future those preparing local lists of insects should keep the above in mind and thus add materially to our knowledge of the distribution of insects.

DRIFTING OR SPREADING OF INSECTS IN VARIOUS GROUPS

There are numerous records relating to the spreading or drifting of various insects in different parts of the world. Some of the more important or better known are discussed in some detail in the following pages.

Butterflies and Moths

Cotton moth. One of the most familiar and striking movements of insects is the somewhat common appearance of *Alabama argillacea* Hübn. at city and village lights in the northern United States and southern Canada, especially in the northeastern states. The moths appear in swarms during the fall, many being so fresh and perfect that one is unable to associate their condition with a purposive, tiring flight of several hundred miles with its great draft

upon vital energies and presumable effect upon the "plumage" of the insect. In other words, weather-worn insects usually show the results of exposure. The above-mentioned facts make it seem more reasonable to believe that these moths, issuing as they do by millions in the cotton fields of the South, allowed themselves to be carried to moderate or even considerable elevations by upward air currents and then drifted through much of the night. Even five hours at the average velocity of our balloons, namely, nearly 18 miles an hour, would carry them a considerable distance, while 50 to 75 miles an hour, a by no means exceptional velocity in the upper air, would enable the insects to cover the maximum distances in one night and permit them to drop in some northern city with no greater expenditure of energy than would be necessary to maintain themselves in the air. The fact that the flights of the cotton moth are observed in the northeastern United States more frequently than in areas directly north of the cotton sections and much more commonly than in areas westward, would suggest that the insects drift on southwesterly winds. Here again we have a reasonably close connection between known wind currents and the flight of this moth. R. W. Braucher of Chicago associates the cotton moth with high pressure on the Atlantic coast and a south wind. Recent advices from Professor F. L. Washburn of Minnesota indicate the rather infrequent appearance of the cotton moth in Minnesota, while the insect appears to be unknown in North Dakota (except for one record, namely, Beach, just on the Montana line August 23, 1924, C. N. Ainslie), Montana, Idaho, Wyoming, Utah and Oregon, states northwest rather than north of the larger cotton-producing areas. R. A. Leussler of Omaha records its appearance several times during the past 17 years in eastern Nebraska, while Professor T. D. A. Cockerell informs us that a large flight occurred at Boulder, Colo., in 1914, the same year that the insect was so abundant at St Paul, Minn. This flight, so far as the north-central United States and the midwestern areas are concerned, represents presumably unusual conditions, especially since Professor C. P. Gillette of Fort Collins states that he has never seen the insect in Colorado.

It is interesting in this connection to place on record the opinions of Dr W. E. Hinds of Louisiana, formerly of Alabama. He writes as follows: The cotton "moths are known to be powerful flyers, and we frequently have reason to believe that infestation in the Gulf States starts from moths which have flown across the gulf from Central or South America. The movement is always predominantly in a northerly or northeasterly direction." We are inclined to believe,

as stated previously, that the insect's power of flight is somewhat overestimated in this statement. The movement in the same general direction as occurs in the United States is worthy of notice.

The following records are somewhat significant. A. R. Grote, an early authority on the Lepidoptera, states (1874, p. 725) that data are at hand to show that for many years after the cotton plant was introduced in the Southern States, the cotton worm never appeared. He states that it was evidently first recorded from central Alabama but little preceding the Civil War. This suggests that the original infestation in the Southern States probably came about through drift across the Gulf of Mexico. Grote also refers to the well-known flights of this insect to the northern United States.

The somewhat common appearance at city lights in New York State of millions of such insects as the snow-white linden moth, *Ennomus subsignarius* Hübner and the lime-tree winter moth, *Erannis tiliaria* Harris, are with little question due largely to wind drift for considerable distances and are therefore comparable in some measure to what is known regarding the movements of the cotton moth discussed above.

The actual rising of insects in the air prior to migration is of considerable interest, and on that account there is inserted here observations by a veteran entomologist, Richard South, (1885, p. 209-10) in relation to the behavior of a moth identified with little question as *Plusia gamma* Linn. at Ventnor on the Isle of Wight in 1879. Sunday evening, August 10th, he was walking over the downs on the west side of the town. The day had been hot and the evening was calm and sultry, not a breath of wind stirring from any quarter. Conditions indicated a thunderstorm, and this occurred during the night. He observed numerous moths towering upward in a spiral flight, and as the light was fast declining they were soon lost to view. There were so many that he concluded that these peculiar movements were connected with the migration of the insects from their breeding ground. They ascended without an apparent inclination toward any particular point, and in his estimation would probably have been influenced by any current of air they may have reached. It appeared to him as the simultaneous movement of a large number of moths and not the action of a few individuals. A similar movement by this species but with no suggestion of unusual meteorological conditions is described by Robert Adkin in *Nature* (1925, p. 467). Later, it may be found that this is the normal way for the species to take flight.

It should be noted that the cosmopolitan *Nomophila noctuella* Den. & Schiff. has been recorded as a probable migrant to the Hawaiian Islands (Fauna Hawaiiensis, p. xlvii-xlviii).

Australian noctuid. There is a record of the noctuid, *Agrotis spinata* Guen., assembling in immense numbers in Australia, the insects occurring in such extreme abundance as to approach a veritable nuisance in dwellings and public assembly places and seeking shelter amid rocky mountain summits in such tremendous numbers that the natives had become accustomed to gathering the moths and after proper roasting using them as an article of food. This appears to be a mere swarming instinct developed to an extraordinary degree rather than the drifting of insects with favorable winds, although under certain conditions this species may have been found in numbers at sea far from land.

Blue page moth. The effect of severe storms and the possibilities of a long drift upon insect distribution is at least suggested by the following:

The "Blue Page" Moth.—During the gale that reached Barbados and St Vincent on August 26, 1901, numbers of a large moth were found in Barbados, of a kind not known to breed there. They had evidently been brought by the high southwest wind. Some were caught and identified as *Urania sloanei*, the "blue page" of Trinidad itself. They were found as far north as Dominica, and one was caught on the R.M.S. "Eden" midway between St Lucia and Barbados. This is an excellent instance of how insects spread from island to island, and had these moths found suitable conditions in Barbados, they might have become established there and formed an addition to the permanent fauna. The direct distance from Trinidad to Barbados is about 160 miles, and to Dominica is some 100 miles more.—*The (Barbados) Agricultural News*, June 7, 1902.

Corn ear worm moth. This insect, *Chloridea obsoleta* Fab., probably does not winter in any numbers north of southern Pennsylvania and the Ohio river. Occasionally it becomes extremely abundant and injurious in northern United States and southern Canada. The known facts do not suggest the flight of such enormous numbers as in the case of the cotton moth, and yet it works northward somewhat rapidly, presumably relatively few individuals drifting with the wind, depositing eggs and soon producing a serious infestation. The short period necessary for the completion of the life cycle makes this entirely possible.

Various migrants. The subtropical black witch, *Erebus odorata* Linn., very probably comes north on the night winds, since specimens have been taken in the northern United States and

even in southern Canada in such perfect condition as to suggest recent emergence from the pupa. The closely related *Thysania zenobia* Cram. has been taken in New England on at least two occasions according to C. W. Johnson of the Boston Society of Natural History, and has also been taken in New York State. The tropical sphingid, *Arges labruscae* Linn., has been recorded from Aroostook County, Maine, by Doctor Johnson. Dr. W. T. M. Forbes of Ithaca advises us that he is quite sure that a number of captures in trap lanterns operated at Ithaca are migrants, citing in particular *Laphygma frugiperda* Sm. and Abb., *Pilocrocis ramentalis* Led. and *Anticarsia gemmatilis* Hübn. The following southern forms, *Autographa oxygramma* Geyer, *Anomis erosa* Hübn. and *Anticarsia gemmatilis* Hübn., were taken at Rye, Westchester county, N. Y., by Henry Bird in connection with the large cotton moth flight of 1912.

It should be noted that none of these records can by any possibility include all of these insects carried so far from their normal habitat. They probably represent an extremely small percentage of the total. Furthermore, the drift in almost every instance is northeasterly and therefore agreeing in the main with the winds prevalent in this country. Additional data along this line are given under mountain and glacier data.

Local dispersal. There are many records relating to the spread of various species over smaller distances. It is hardly advisable to attempt to include them all. We are giving a few which have come to notice in recent years. William C. Cook of the Agricultural Experiment Station, Bozeman, Mont., states that in the spring of 1920 there was an enormous flight of the army cutworm, *Chorizagrotis auxiliaris* Grote, all over Minnesota, Iowa and northern Missouri. He found by examination of available literature that the nearest breeding ground to any of these localities was along the boundary between North and South Dakota and Montana. The prevailing winds at that time of the year are from the west and northwest so that wind drift would easily explain the presence of this species in Minnesota and the other states. He considers it most probable that the moths must have covered at least 500 miles in their flight.

Mr Cook also calls attention to a shorter migration in the fall of 1919. The adults of the pale western cutworm, *Porosagrotis orthogonia* Morr., were very abundant in the dry land country northwest of Three Forks, Mont. This particular region, he states,

is a sort of a basin sheltered by rather low ridges but open to the west winds. During the period of flight of these moths there were several times when there were strong west winds, and in the following year practically no infestation occurred in the basin except against the foot of the mountain on the eastern end. There was also another infestation reported from the Spring Hill bench of the Gallatin valley about 20 miles directly east, the winds apparently carrying the majority of the moths over against the foothills on the east side of the basin or on past there and into the Spring Hill country.

The spread of the apple and thorn skeletonizer moth, *Hemerophila pariana* Clerck, northward in the Hudson valley during the past few years has been with the prevailing winds, and the distribution is so general, the insects even being found on isolated apple trees on wooded hills miles from any extensive orchards, that one can not escape the conviction that the small moths drifted with the winds. During the season of 1922 there was a definite northward extension of this insect over 50 miles. A further spread of even greater extent was recorded in 1923 by Dr M. D. Leonard. Very much the same movement with the winds appears to obtain in the case of moths of the spruce bud worm, *Harmologa fumiferana* Clem., in Maine, according to statements made recently by H. B. Peirson, forest entomologist, Augusta, Maine.

Migration and dispersal of insects have been discussed by J. W. Tutt in an interesting series of articles to which one may refer for numerous details. The following are the references to the entire series:

Entomologists Record and Journal of Variation

- 1898 General Considerations 10:209-13
- 1898 Coccids and Aphids 10:233-38
- 1899 Orthoptera 11:14-18, 43-45, 64-67, 89-93, 117-21
- 1899 Odonata 11:153-55, 181-83, 213-15
- 1899 Lepidoptera 11:319-24; 1900, 12:13-16, 69-72, 127-28, 182-86, 206-9, 236-38, 253-57; 1901, 13:97-102, 124-25, 145-47, 233-37, 255-56
- 1901 Coleoptera 13:281-84, 198-201, 317-20, 353-58; 1902, 14:73-75
- 1902 Diptera 12:173-81
- 1902 Hymenoptera and Termites 14:207-14, 232-37
- 1902 Final Considerations 14:262-65, 292-95, 315-19

See also the following papers by Professor C. B. Williams, Government Entomologist of Egypt: XVIII. Notes on Insect Migration in Egypt and the Near East, Transactions Entomological Society of London, Parts 3-4, p. 439-56, 1925; Some Unsolved Problems of Butterfly Migration, Internationaler Entomologen-Kongress, Band II, p. 100-8, 1925; Voluntary or Involuntary Migration of Butterflies, The Entomologist, November 1926, 59: 281-88; Records of Migratory Insects, Chiefly from Africa, Bulletin Societie Royale Entomologique d'Egypte, p. 224, 256, 1927.

Monarch butterfly. This insect, *Danaus archippus* Fab., moves freely over a wide territory. Although unable to survive the winter north of subtropical areas, yet each season it makes its way into Canada, sometimes nearly to the Arctic ocean, and is known to occur southward through the West Indies and Central America to South America, probably to the Amazon river and Bolivia, and if *erippus* Cram. is merely a geographical race, to the mouth of the Rio de la Plata.

The behavior of the monarch when migrating has been well described by the late Dr Otto Lugger (1889, p. 256-58). He camped for several days near Battle Creek, Mich., in August 1888. During the day but few butterflies could be seen flying about in search of food but toward sunset large numbers of them came from all points of the compass and settled upon the trees, selecting the crowns. As long as it was light butterflies arrived and millions of them must have crowded together. Early in the morning the butterflies began to leave the grove not singly but in large numbers which broke up into smaller companies to scatter over the prairie in search of food. He stated that the butterflies assembled every evening for at least ten days and very likely for a longer period, as the wind during that time was from the south. They dispersed with the first wind from the north.

Discussing the movements of the monarch, Tutt (1902, p. 292-93) is inclined to regard the fall assembling of this species as a mere roosting habit and considers that no proof has been adduced to indicate a real southern migration. He rightly claims that more exact data are necessary before a well-established north and south migration can be admitted for this species, adding that no European lepidopterist believes there is an autumnal return movement in the case of *Vanessa cardui*.

It is interesting to note Professor V. L. Kellogg (1904) states that the monarch butterflies commonly winter on Point Pinos peninsula, Bay of Monterey, Calif., in great clusters or festoons some 50 miles from any quantity of their food plant. The insects do not remain immovable during hibernation but may be seen fluttering about flowers on any bright day. It is quite possible, in view of the above, that the assembling so frequently recorded for this insect in northern localities is simply an instinctive movement prior to hibernation and not necessarily an assembling for migration.

The spread of this butterfly southwestward is most remarkable, it having been reported by various parties from such widely separated and in some cases inaccessible parts of the world as follows: Hawaiian

islands, Ponapi in the Carolines, the Society islands, Cook islands, Marquesas, Oparo or Rapa island, Samoan islands, Fiji islands, Tonga or Friendly islands, Loyalty islands, New Hebrides, Duke of York island, Norfolk island, New Zealand, North and South islands, Australia, Tasmania, Solomon islands, New Guinea, Louisiade islands, New Britain island, Celebes, Java, Sumatra and the Keeling islands.

The above list suggests a general distribution throughout much of Oceania, and the question naturally arises as to how the monarch made its way to some of these remote islands. The longest distance from land to land, assuming that *Danaus archippus* Fab. is American, is 2000 miles between this coast and the Hawaiian islands. Investigations of earlier entomologists, as summarized by Scudder, indicate that the butterfly became established upon the Hawaiian islands not far from 1845 to 1850 (1889, p. 730). There is evidence to show that a tropical milkweed, *Asclepias curassavica*, was established in the island by 1852, *Danaus* being unknown until after the milkweed had been introduced. The summary account of the geographical distribution of this species by Commander James J. Walker (1914, p. 181-93) refers to earlier published observations indicating that this butterfly may have become established in New Zealand as early as 1840. He italicizes a statement to the effect that the old maories were unanimous in stating that the butterfly was there before any white man came. The monarch certainly could not maintain itself upon any of these islands prior to the establishment of a suitable food plant, and the latter evidently did not exist in the Hawaiian islands up to comparatively recent times.

A communication from Professor F. L. Washburn from Papeete, Tahiti, dated August 23, 1925, states that he found specimens of this insect on Takapoto island and saw its larvae feeding on a tropical milkweed.

A letter from Professor J. F. Illingworth of Honolulu, dated February 17, 1925, informs us that the milkweed butterfly is occurring there in tremendous numbers on an introduced African shrub identified by Doctor Brown, the botanist, as *Calotropis gigantea* R. Br., that it is reported to feed in the vicinity of Sydney, Australia, upon *Gomphocarpus ovatus* Schlechter, introduced from southern Africa and in New Zealand it occurs on the related *G. fruticosus* R. Br. from the Mediterranean region. This is somewhat suggestive in regard to the possibilities of this butterfly maintaining itself in other parts of the world.

Scudder, in his review of the wanderings of this insect, suggests that the butterfly may have originally been carried to midocean through some commercial agency, a theory which is not shared by Commander Walker. The latter states that during a cruise between New Caledonia and the Solomon islands specimens of this butterfly were to be seen every day, often in numbers, southeast trade winds prevailing at the time. He records having observed the smaller and less powerful *Danaida chrysippus* at sea 700 miles from the nearest land, namely, off the African coast. He also gives a record of an Archippus captured by a sea-faring friend 600 miles from Cape Race, the nearest land. There is a record of a specimen being captured off the coast of Portugal, 60 miles from St Vincent, apparently one of a number working east from the American continent or possibly the Bermudas. Scudder cites a case where Archippus was found in the South Pacific 500 miles from the nearest land.

In connection with the above, the reader is referred to the September 1925 issue of The Entomologist's Monthly Magazine, pages 198-202, for a general statement by Mr Collenette concerning the present status of this insect in the Pacific islands and indicating a much less general infestation than in 1883.

Turning from the Pacific to the Atlantic, there are records to the effect that this butterfly has been established for a long time in the Bermudas, 650 miles from the American coast. Specimens have been taken occasionally in the Azores, and the Canary islands are recorded as headquarters for this species by Commander Walker, who has also compiled a record showing the appearance of this species at irregular intervals in some portions of Great Britain from 1876 to 1908. He comments upon the great disparity between these records and the very few captures of this butterfly on the continent. N. D. Riley of the British Museum characterizes the insect as "the rarest of chance visitors." F. W. Frohawk, editor of the Entomologist (London), advised us recently that Archippus has not established itself in Great Britain or elsewhere and that there seems to be no likelihood of its becoming established, thus supporting Commander Walker's opinion that the species is a casual visitor in the British Isles. Mr A. J. Wilmott of the Botanical Department of the British Museum of Natural History states that no species of the genera *Asclepias* or *Apocynum* occur in the British Isles, and adds that *Apocynum venetum* is found in South Europe, though very locally. It will be seen that conditions in both Great Britain and continental Europe are not favorable for this insect.

The annual movement of this butterfly in North America from the subtropical areas nearly to the Arctic Circle still remains to be considered. There is no question but what such occurs, the movement frequently being very marked and apparently unhindered by a large body of water such as Lake Ontario. In this connection C. B. Hutchings, assistant entomologist, Division of Forest Insects of the Canadian Department of Agriculture, Ottawa, has placed at my disposal observations made August 24, 1923, at which time there were literally thousands of these butterflies upon some maple trees at Toronto. The insects rested for two days and on the morning of the third they had all disappeared. He was informed by somebody at the time that a large swarm had been seen crossing Lake Ontario, and a few days later, August 30th, he read in the Toronto Mail and Empire a report from New York State to the effect that myriads of milkweed butterflies had been seen fluttering through the cities, drifting more or less with the wind as they made their way southward. The actual crossing of the lake is not established beyond question in this case, although it is strongly probable that this was done. The southward movement of this butterfly, so far as at present recorded, does not suggest the covering of long distances, 500 to 1000 miles within a day as in the case of the cotton moth discussed above. It may be that the better visibility of the daylight hours results in diurnals refusing to allow themselves to be carried to the altitudes which may be attained by moths, since the lower visibility during the night would probably make it more difficult to estimate height correctly. It would therefore seem that the monarch butterfly in its northerly and southerly migrations over land probably takes advantage of favorable winds and drifts through the air at moderate heights, usually dropping to earth at dark and sometimes before. This last is not invariable, however. There is an observation by Dr C. Hart Merriam who stated that in October 1885 a lighthouse keeper on Lake Ontario had been greatly annoyed by the large swarms of monarchs that flew against the lighthouse and obscured the light. There are records of other butterflies, *Eugonia j-album* Bdv.-Lec. for example, appearing at lights, though these are presumably exceptional occurrences.

If it is possible for the cotton moth to remain in the air throughout most of the night, and such seems to be the case, it certainly appears as though the monarch butterfly should be able to do equally well. The drifting records of balloons alluded to above demonstrate beyond question the possibility of a butterfly drifting enormous distances, 1500, 2000 miles or even more within 10 to 24 hours or thereabouts.

The specimens observed near the western coast of Europe, presumably having drifted from American shores, strongly suggests that this is going on. The casual appearance of the insect in the British islands through a series of years also tends to support this idea. The habitual presence of butterflies at sea among the Pacific islands observed by Commander Walker, a thoroughly competent witness, proves that these insects fly or drift over the ocean. It would seem from the evidence at hand that this spread by winds has occurred for many years and that the explanation of the monarch establishing itself in the numerous islands of the South Pacific is that it speedily followed the introduction of its food plant. Drifting in that direction in earlier years simply meant the casual appearance now characteristic of the British islands.

Winds and monarch distribution. The very extended distribution of this insect in the South Pacific suggests, due allowance being made for the variability of winds, that there must have been large numbers of these butterflies drifting or flying over the ocean. The general trend of the trade winds from east to west and particularly those of the northern hemisphere from northeast to southwest would be exceedingly favorable for the drifting of this insect to the Hawaiian islands, and with the variability common to winds, particularly during periods of storm, it is by no means impossible that air currents would carry this insect southerly and southwesterly across the Equator and provide the wide distribution in Oceania.

An examination of the Atlas of Meteorology (Bartholomew and Herbertson, 1889, plate 14) shows there are during the months of July and August northwestward winds impinging on the western coast of North America and swinging away from the land in latitude of about 35° N., and becoming northeastward, a trend directly toward the Hawaiian islands. The winter winds in the mid-Pacific are northeast with a distinct northern component south of the Equator, which in connection with the normal variability of winds would result, in the course of several seasons at least, in the distribution of a strong flying butterfly such as the monarch throughout Oceania and even to Australia and New Zealand, provided the insect was able to maintain itself upon some of the islands, something which has been true within historic times.

The southeast currents in latitude 20 south or thereabouts on the western coast of South America would also be favorable for the distribution of this insect throughout Oceania, even if they only lent impetus to the westward drift when they join the northeast currents from the northern hemisphere in the region of the Equator.

Discussing the effects of tropical cyclones in the Pacific, Professor S. S. Visher (1925, p. 70-78) suggests that it is highly probable that tropical cyclones have played a part in the dispersal of life from island to island in the Pacific, and adding in explanation of the marked oriental influence in the fauna that often violent westerly winds completely overcome the prevailing easterlies. He cites the occasional power and persistence of this westerly wind by referring to the case of John Williams, a missionary who drifted in an open boat 500 miles from Hervey island to Tahiti, a record published by him in 1838. He also refers to hundreds of dragon flies being carried presumably from Sumatra and Java across the 700 miles of ocean to the Cocos-Keeling islands in the Indian ocean.

The possibility of winds carrying the monarch butterfly across the Atlantic to Great Britain is strongly supported by the prevalence during midsummer of southwest winds on our Atlantic coast sweeping across the ocean, and certain currents at least centering squarely upon the British islands. This condition goes far toward suggesting an explanation for the relatively common occurrence of this butterfly in England where it is unable to maintain itself, and the relatively much greater scarcity in adjacent continental areas. It would be expected, were insects able to drift across the Atlantic ocean, that they would drop on the first available land of any size and this seems to be true of the British islands.

If it is assumed that normal wind currents are inadequate to transport this butterfly the immense distances necessary to assure its appearance in widely separated parts of the world, which by no means is granted, let us turn for a moment to the data available in relation to storm tracks, since certain storms at least move very rapidly, and presumably there is a greater acceleration of air currents during storms than at other times. Bartholomew's Atlas, cited above, on plate 29 shows that storm tracks from the northwest occur in Oceania in January, February, March, April, November and December, periods when the monarch butterfly would fly in that section of the world. These movements would be most favorable for the distribution of the insect throughout Oceania, provided it had previously obtained a foothold in the mid-Pacific, as for example in the Hawaiian islands.

The same plate illustrates storm tracks during the months of May, June, July and October, mostly periods when the milkweed butterfly would be on the wing, crossing the ocean from the eastern United States to the British islands. In August and September, months when the butterflies appear most frequently in England,

the storm tracks are not so far north of the British islands that the latter would be outside of the area of disturbance.

A number of these storms at least diverge some distance west of the British islands and sweep north to the Scandinavian peninsula, or to be more specific, the storm tracks of this period commonly extending to southern Europe cross the British islands while others sweep considerably to the north, following a much longer course over the ocean before they reach northwestern Europe. It follows, if this butterfly is carried by winds, that both the normal air currents in the North Atlantic and the storm tracks would make it more probable for this butterfly to drift to the British islands than to any other section of Europe.

Red admiral. It should be noted that the cosmopolitan *Vanessa atalanta* Linn., was recorded from the Hawaiian Islands for the first time in 1899 and that the allied species, according to Professor O. H. Swezey of Honolulu, the painted lady, *V. cardui* Linn., and the painted beauty, *V. huntera* Fabr., are both found on all of the Sandwich islands. It is not known whether the latter two have been there long or whether they antedate the appearance of the red admiral, *V. atalanta* Linn. It is at least interesting that these three butterflies should become established in the mid-Pacific, possibly being carried there within recent years by wind currents. If this last be the case, butterflies were presumably prevented from establishing themselves earlier in the Hawaiian islands on account of the lack of satisfactory food plants. This would certainly agree with the conclusions regarding the monarch butterfly and is supported by the following excerpt from a letter from Professor J. F. Illingworth of Honolulu dated March 3, 1925, in reply to a suggestion as to the probability of this being the explanation:

Your conclusions are also good in regard to the three species of *Vanessa*. Any chance wind introductions of prehistoric times probably failed to become established because of a lack of suitable food plants. At any rate, today we find these butterflies developing on plants of American introduction. We naturally conclude that the seeds of these plants have come by ships, during the last century, yet, there is a possibility that they also could have come by wind currents. It certainly would be easy for the plumed seeds of the milkweed, thistle etc., to be so carried.

A communication from Professor O. H. Swezey of Honolulu dated March 13, 1925, states that the caterpillars of *Vanessa atalanta* feed on the leaves of a native Hawaiian tree, *Pipturus albidus*, related to the mulberry and assigned to the Urticaceae

in the Hildebrand flora. The tree, he states, occurs on all the islands and it seems strange under the conditions that *atalanta* does not occur on any of the other islands, since if the insect could reach Hawaii from the mainland it would seem that it would be far easier for it to spread to the other islands of the group. He states that even yet the caterpillars feed only on the native *Pipturus*. Respecting *Vanessa cardui* and *V. huntera*, he states that the larvae feed only on introduced American plants and there is therefore no reason for modifying the above statements in respect to these two.

Some may be inclined to hold that the velocity of the trade winds is entirely inadequate to account for the extended flights, since the butterflies must necessarily traverse wide stretches of either ocean. We should remember that wind velocities increase materially with altitude and that only a moderate elevation above the ocean gives a considerably more rapid drift.

Painted lady. The movements of the cosmopolitan painted lady or thistle butterfly, *Vanessa cardui* Linn., are very suggestive. This insect does not appear upon the wing in central Europe, except the migrating butterfly, until the middle or end of July. An immense number appeared in May and early June in 1875 in central Europe, even crossing the Alps and suggesting in appearance flight from an immense distance. Oberthur stated that specimens captured belonged to a very characteristic African type. The butterflies remain on the wing the entire winter in northern Africa and breed throughout the season in Egypt. Therefore these insects probably found their way from distant Egypt. This seems very reasonable, in view of the fact that an estimated $5\frac{1}{2}$ inches of dust swept from the Sahara by the sirocco during the past 30 years has been deposited in Europe and that this dust has been distributed also over parts of Africa, Asia and the Atlantic ocean. Dust from Australia has been carried 1500 miles to New Zealand (Hurd, 1922, p. 301). Scudder refers to similar spring flights which occurred in 1741, 1790, 1798, 1826 and 1851 and an exceptional one in October, 1827.

The beginning of a supposed migration has been graphically described by Skertchley (1879, p. 266). He states that some of the swarms at least originate in Africa, one of which he observed a day's march west of Sowakin in Nubia in March, 1869. At the foot of the high country is a stretch of wiry grass, beyond which lies the rainless desert. The whole mass of grass seemed violently agitated, although there was no wind, and observation disclosed that the "motion was caused by the contortions of the pupae of *V. cardui*, which were so numerous that almost every blade of grass seemed to

bear one. * * * Presently the pupae began to burst and the red fluid that escaped sprinkled the ground like a rain of blood. Myriads of butterflies, limp and helpless, crawled about. Presently the sun shown forth and the insects began to dry their wings; and about half an hour after the birth of the first the whole swarm rose as a dense cloud and flew away eastward toward the sea. I do not know how long the swarm was but it was certainly more than a mile and its breadth exceeded a quarter of a mile."

The above is suggestive as to the origin of a swarm, certain phases being practically duplicated by this species in the western hemisphere. Recently Williams (1925, p. 535-37) a close student of insect migration, has summarized the data relative to this species and concludes that all Europe north of a line through the middle of France and south Germany or Switzerland depends for its painted lady butterflies entirely upon migrations from the south, mostly Africa, although even the north coast of that continent does not apparently represent the origin of these insects, since they have been observed entering Algeria from the south and have been seen crossing the Nile valley near Cairo in thousands, coming from the South-eastern Desert. He states that the butterflies tend to fly into the wind, rather than with it, and in the case of one or two records from localities with daily change in wind direction due to land and sea breeze, there is a corresponding daily change in the direction of flight.

Shifting to the New World, E. A. McGregor of California (1924, p. 70-71) records a flight of this species from April 11th to 13th, the flight being from the southeast to the northwest and with an average of about 300 butterflies an acre at a given moment. He believed the source of the migration was either the foothills of the Sierras or the Sierras proper. This flight occurred during the warmest period which had occurred that season, the temperature maximums ranging from 80 to 88° F., and ceased with a sudden drop in temperature. The flight was estimated to have been at least 40 miles in width, and, as it lasted for 36 flight hours, the total distance covered approximately 432 miles, the number of butterflies being estimated at three billion.

Later the same year (May 10th) R. E. Campbell recorded a very extended infestation of weeds, mostly malva, thistles and nettles, by the caterpillars of this butterfly. He stated that the flight and succeeding infestation covered the entire area of southern California as far north as San Luis Obispo.

Two years later, March 20-26, 1926, E. A. McGregor again observed a similar flight (1926, p. 38) the movement being of the same general character as that observed earlier.

These flights on the west coast, taken in conjunction with the observations upon this insect in Europe and Africa suggest that there may be an extended movement by this insect in the New World as well as in the old.

Other butterfly movements. The southern swallow-tail, *Iphiclidia ajax* Linn. var. *telaemonides* Feld., is restricted in its food plant to papaw, and yet a specimen was taken in the town of Elba, Essex county, N. Y., on the road to Keene, (Watson and Coleman, 1912, p. 4-6), elevation 2000 feet, in the center of the Adirondacks and at least 200 miles from the nearest locality where its food plant is known to occur. This magnificent butterfly was taken there on the flowers of the great fireweed, *Epilobium angustifolium*. It by no means follows that this butterfly made its way from the nearest locality where its food plant is known to occur. More probably it came from considerably south.

T. Thorncroft records (1865, p. 289-90) the behavior of certain butterflies about Brighton, England, in July when the flood tide set in at Shoreham Pier about 3 p. m. With a gentle breeze, there came a host of butterflies, *Pieris daplicide* Linn. and a few *P. napi* Linn. Hundreds arrived within a very short time. Most surprising of all, butterflies were seen alighting or settling on the sea with expanded wings, and in one case the same butterfly settled and rose as many as four or five times within a distance of less than a hundred yards and apparently with as much ease as on the land. These insects all came directly in from the sea from the southwesterly direction and Mr Thorncroft evidently was of the opinion at the time that they drifted in from the open ocean.

Robert K. Fletcher (1926, p. 106) records a great migration of the snout butterfly, *Libythea bachmanni* Kirt., at College Station, Texas, September 23, 1925, stating that there were thousands of the butterflies proceeding southward against a gentle south breeze at an estimated speed of eight miles an hour, the great majority flying within three feet of the ground. Twelve hours later a "norther" struck College Station and the temperature dropped to 65°, while the wind changed to the north and increased to 20 miles an hour. It appears possible that the insects may have been driven down by the cool conditions of the upper air,

although the "norther" failed to drop to the surface of the earth until about 12 hours after the swarms of insects attracted notice. We may have here the same phenomenon as that recounted by Hudson (see page 115), except that the dry cold *pampero* of the Argentine is a more violent wind and ordinarily drops quickly to the surface of the earth and consequently there is little interval between the appearance of hosts of the insects and the strong cool wind.

The local movements or migrations in Trinidad of a yellow butterfly, *Catopsilia statira*, have been carefully studied by C. B. Williams (1919, p. 76-88), who records a very general movement of the insects on that island, in places in enormous numbers, some at least crossing to the mainland. It is believed that the swarms originated in the forests of the southeastern and northeastern districts of the island, the general trend being westward and there being seven records of flight over the sea. It is stated that the flight of migrating butterflies is very distinct from those flying casually, the rate varying from 12 to 16 miles an hour and across the wind. It is held that the direction of the wind is not a determining factor in establishing the direction of flight. The numbers observed varied from two or three occasional specimens to so many as to interfere with the progress of a motor car, the immense numbers in one case causing turkeys to gobble in consternation. The flight was almost always in bright sunshine and whenever a cloud passed over the sun there was an immediate dropping in the numbers passing. Other observers state that there is a swarming of this butterfly nearly every year somewhere on the island.

The wanderings of the little sulphur *Euremma euterpe* Men. (*Terias lisa* Boisd.) are briefly noticed by Doctor Lutz (1918, p. 138). He states that there are three broods and that he is not sure how the northern winters are passed, although he thinks the species may work south in much the same way as the monarch, *Danaus archippus* Fab. He also states that "clouds" of the autumn brood have been noted as landing on Bermuda from the northwest, having covered 600 miles of ocean.

European Corn Borer. The spread of *Pyrausta nubilalis* Hübn., in America is very suggestive of windspread, particularly that in the Great Lakes region. It should be recalled in this connection that the insect was first found in western New York, Erie county, N. Y., in September 1919 at North Collins and a little later discovered at St Thomas, Ontario, Canada, the latter infestation being much larger and more severe. The data

which has gradually been accumulated since the finding of the insect at St Thomas suggest that this may be the original point of dissemination for the entire western area. The finding of a scattered and almost continuous infestation in the fall of 1921 or the spring of 1922 along the nearly 200 miles of the southern and western shore of Lake Erie from Ripley, Chautauqua county, westward and northward to a little north of Detroit, is alone very suggestive. The very considerable eastern and northern spread in Canada in 1921 also tends to corroborate this idea, the distance covered in this latter area being at least 30 miles and in all probability greater. There was some extension of territory in this region in 1922 and at the end of 1924 there had been a very material extension in the United States south and west of Lake Erie. This was followed in 1925 by a still further extension northerly and somewhat westerly in Michigan, easterly and southeasterly in New York and Pennsylvania, respectively, and northeasterly along the northern shore of Lake Ontario and the St Lawrence river to a point about opposite Ogdensburg, N. Y., a portion of this easterly extension in Canada being forecast since July 1922 by the finding of isolated infestations along the northern shore of Lake Ontario to Brighton in Northumberland county. The year 1926 was marked by a considerable eastward extension of the western infested area, apparently wind-spread. Furthermore, marked individuals have been recovered 20 miles from the point of liberation and it is known that the moths may alight upon the water and again take flight. There are now some 55,000 square miles of infested territory centering upon Lakes Erie and Ontario and indicating a very much greater relative spread than has occurred in either the eastern area in New York State or the infested section in eastern New England. Even in this last there were marked extensions in 1922 northeasterly and northwesterly into Maine and New Hampshire, both likewise suggestive of windspread. The recently published "Progress Report" by Caffrey and Worthley (1927) gives data very suggestive of extensive windspread.

In view of the fact that insects are now known to be carried to considerable heights by convectional currents, that the upper air moves with a relatively high velocity and that insects with supposedly very limited powers of flight have presumably been carried long distances by favorable winds, it seems quite within the possibilities to attribute much of this enormous spread in the lake regions in particular to the influence of the winds. Additional evidence in support of this is found in the greater easterly spread, assuming

St Thomas, Ontario, Canada to be the location of the original infestation. This, if true, indicates that westerly and southwesterly spread will be checked to some extent by the prevailing westerly and especially northwesterly winds, though it is too much to expect that these air currents will do more than slow up the progress of this pest toward the corn belt states, westerly and southwesterly of the present infested area.

Hymenoptera

Striking examples of widespread distribution among the Hymenoptera are to be found, though they are not so numerous as in other groups. The larch sawfly, *Nematus erichsonii* Hartig, first came to the attention of Dr A. S. Packard in August 1882 at Brunswick, Maine, and at about that time it was also found in Massachusetts and in the Adirondacks in New York State. The insect was defoliating large areas and evidently was spreading rapidly. It is now widely distributed in the northeastern United States and southern Canada. The elm leaf miner, *Kaliotenus ulmi* Sund., is another introduction which appears to be spreading rather rapidly, although there is a possibility of its having been carried with shipments of nursery stock. The birch leaf miner, *Fenusa pumila* Klug., was first observed in Connecticut in 1923 and is now widely distributed throughout southern New England at least and much of eastern New York State. The spread of the above-mentioned larch and birch insects was probably due in large measure to favorable wind currents and the same may be true of the elm leaf miner.

There are a number of records of ants being found far from their normal habitat, presumably having drifted on air currents. Professor W. M. Wheeler calls attention (1910, p. 145) to the occident ant, *Pogonomyrmex occidentalis*, a species peculiar to the Great Plains, being taken in Hawaii, and the finding in Massachusetts of a single colony of *Formica neoclara*, an ant restricted so far as known to the mountain valleys of Colorado. There is also the record of the southern *Aphenogaster tretaetae* Forel. subsp. *wheeleri* Mann, on Naushon island opposite Woodshole, Mass., (*Psyche* 1915, 22:51). The one colony of *Bothriomyrmex dimmocki* Wheeler on Mount Tom, Mass., (*Amer. Mus. Nat. Hist. Bul.* 1915, 34:418), at least suggests an insect far from its native heath, since allied species are known only from the Mediterranean, southern Asia, Java and Australia.

Diptera

There are not many records relative to widespread movements of the Diptera or true flies, although a number are undoubtedly carried considerable distances by air currents. One of the best known of these is the salt marsh mosquito, *Aedes sollicitans* Walk., a species which is known to occur in immense numbers 40 miles from any possible breeding place and presumably drifting with the winds.

The Hessian fly, *Phytophaga destructor* Say, probably drifts considerable distances, measured in miles, judging from the somewhat uniform infestation which may be found over considerable areas.

Gurney and Woodhill (1926) demonstrated a flight of at least ten miles for *Chrysomya albiceps* Meign. and a nearly equal distance for *Anastellorhina augur* Fabr. and *Neopollenia stygia* Fabr., all sheep blowflies stained and liberated in large numbers, the majority of the flies traveling with or slightly across the wind.

The Mexican Dexid, *Cholomyia inaequipes* Bigot, has been taken at Ithaca, N. Y., by Dr O. A. Johannsen and recorded from Long Island and New England by Dr C. W. Johnson. The capture of the Pacific states *Tabanus septentrionalis* Loew in several New England localities and New York State is at least suggestive.

Some other data relative to members of this group will be found in the discussion of small insects and winds.

Coleoptera

Beetles or Coleoptera are rather heavy insects and yet there is no question but that some species travel considerable distances. The historic spread of the Colorado potato beetle *Leptinotarsa decimlineata* Say, throughout the eastern United States reveals an average eastern progress of approximately 80 miles a year. The insect is well known as a strong flyer and in early spring may be observed moving rapidly at moderate elevations and possibly at considerable height. The occurrence of numerous specimens in the Lake Michigan drift is also conclusive evidence that this beetle moves freely in the air.

The Pales weevil, *Hyllobius pales* Boh., is attracted from long distances to fresher cut areas, according to H. B. Peirson (1921, p. 16-17) now forest entomologist of Maine. This results in concentrating its attack on areas where young seedlings are just coming

up to replace the cut timber. Somewhat the same conditions have been repeatedly recorded for various bark beetles, especially those belonging to the genus *Dendroctonus*, there being instances of swarms of considerable size invading certain areas. The difficulty in all these cases is to obtain definite information as to the distance covered. It is quite probable that to some extent at least certain species are guided by odors and therefore fly against the wind, especially pine weevils and bark beetles.

The recorded spread of the Mexican bean beetle, *Epilachna corrupta* Muls., as outlined by the workers of the bean beetle laboratory of the Bureau of Entomology, in the eastern United States since its discovery in Alabama in 1920, suggests most strongly the influence of southerly winds carrying the insect in a northerly direction with a distinct easterly trend, the insect at the end of the season of 1924 having been recorded from much of the territory north of southern Alabama and extending nearly from the Mississippi river to the slopes of the Appalachians northward practically to Lake Erie, a spread in this direction of about 150 miles a year. The general trend or spread is such that one might be justified in believing that the swarms of the cotton moth in the fall follow a somewhat similar course in the initial part of the flight, although since presumably they rise higher in the air than does the Mexican bean beetle, the influence of the Appalachian mountains would be less marked in the greater distance covered within a short time and would result in many of the insects dropping as they do to lights in the northeastern United States.

The distribution of the cotton boll weevil, *Anthonomus grandis* Boh., within recent years was closely mapped by agents of the Bureau of Entomology, United States Department of Agriculture, and here likewise a northeastward distribution is evident, being particularly so in the early history of the insect in the United States.

The marked eastward distribution as compared with the northern was more apparent than real and due in considerable measure to the restricted distribution of its food plant. This northeastward spread has also been recorded for other insects, notably the Harlequin cabbage bug, *Murgantia histrionica* Hahn.

A remarkable collection of lady beetles is recorded by Piper (1897, p. 49-51). In July 1893 he found on the summit of Moscow mountain, Idaho, altitude about 5000 feet, immense numbers of dead lady beetles, about ten thousand being found within an area of one square foot under a flat piece of rock. The following July

Professor Aldrich found the lady beetles, *Coccinella transversogutata* Fald., in the Blue mountains, Washington, at an elevation of 5000 feet. In neither case was there evidence of nearby aphid infestation. There are a number of other similar records in relation to lady beetles for both America and Europe. This habit of assembling in large numbers at considerable elevations is taken advantage of by Californian horticulturists who collect the beetles for the purpose of liberating them in aphid infested areas.

There is a record of what appears to be a somewhat definite drifting or migration with the wind of a Hispid leaf-miner, *Coelaenomenodera elaeidis* Maul., on the Gold Coast, Africa, the beetles leaving a locality as soon as food material becomes short and moving along the Akwapim ridge in a southwesterly direction for a maximum distance of some 16 miles. The map indicates a prevailing northwesterly wind, the storms coming from the northeast. The ridge has elevations from 1000 to 1500 feet and it seems very probable that the lower winds at least would be modified by these elevations and follow a mostly southwesterly course, the direction recorded for the drift or migration (Cotterell, 1925, p. 77-83).

Hemiptera

The taking of *Thamnotettix pallidulus* Osb. at Presque Isle, Pa., by Professor De Long (1923, p. 365), a western species described from Iowa, and recently cited from Kansas, appears to be another case of an insect being found a considerable distance from its normal habitat. Another Homopteron, *Dorydiella floridana* Baker (De Long, 1923, p. 367), was also taken in that locality by Professor De Long, the nymphs being found on the stems of a rush, *Scleria verticellata*, just above the surface of the ground and within the clump. This is considered a typical southern species, although it has been recorded in small numbers from Massachusetts, New Jersey, Illinois, along Lake Michigan and in a similar lake habitat in South Dakota, apparently being restricted to sandy areas. There are grounds for believing that certain southern insects are able to sustain themselves on sandy areas considerably north of their normal habitat. While this insect was probably permanently established at Presque Isle, since it was observed in numbers for the past four seasons, it is very possible that air currents may have been important factors in establishing the species in these widely separated localities and possibly in reestablishing it repeatedly when extreme conditions may have resulted in local extermination.

The beet leaf hopper, *Eutettix tenella* Baker, has a well-known migratory habit. Professor H. H. Severin of California states in a letter dated July 7, 1925, that in the spring of 1919 three immense swarms of this insect flew from the plains and foothills into the cultivated areas of the San Joaquin valley. A study of the situation showed that the insects flew from the coast range to the foothills of the Sierra Nevada mountains, a distance of 50 miles. He further states that beet leaf hoppers have been taken as far north as Red Bluff in the northern extremity of the Sacramento valley, a distance of about 200 miles from the northern limit of their breeding range, and adds that light winds probably play an important part in the dispersal and migration of this insect. It would seem very probable from the above that these movements depend to a considerable extent upon favorable air currents.

There appears to be definite movements of this insect in southern Idaho, according to data kindly supplied by Asa C. Maxson of the Great Western Sugar Company. He states that the breeding grounds are 40 or more miles from some of the beet fields, that the hoppers appear in these fields nearly every year, although they seem to make the trip in easy stages. He adds that in 1924 beets about Buhl, Idaho, were destroyed by June 10th and a few hoppers were present 50 miles east, that much farther from the breeding area, and that in two weeks the eastern portion of the beet-growing territory was heavily infested.

Odonata

There are a number of early records suggesting extended flights or drifting by dragon flies. Robert McLachlan (1900, p. 222-26) gives comments and observations in relation to an extended flight in Belgium, June 5th-10th of that year. The insects were observed over a line from the southwest to the northeast of some 106 miles and for a distance from southeast to northwest of over 62 miles. In both cases the flight occurred in the morning in opposition to the prevailing winds. It is stated that on June 10th the insects came from the sea and on the 5th flew against the wind, keeping rather low and flying with astonishing regularity and without resting, the flight being estimated in one locality at about 11 miles an hour. It is suggested that these dragon flies may have flown out to sea and then, discouraged by conditions, returned. McLachlan states that there are indications that part of the swarm reached England, not that it originated in England.

A somewhat similar flight of dragon flies was observed October 13, 1915, at New London, Conn. (Osburn, 1916, p. 90-92). The insects came from the north and did not appear at all shy. The body of the swarm had entirely passed at the end of an hour and after 3 o'clock only occasional stragglers were seen during the remainder of the afternoon. The species proved to be *Anax junius* Dru., the sexes being equal in number and the insects at the height of flight so abundant that the air seemed suddenly to become filled with large dragon flies.

There is a singular account by W. H. Hudson (1892, p. 130-34). The most common species inhabiting the Pampas and Patagonia is *Aeschna bonariensis* Raml. The really wonderful thing, he states is, "That they appear only when flying before the southwest wind, called the *pampero* — the wind that blows from the interior of the Pampas. The *pampero* is a dry cold wind exceedingly violent. It bursts on the plains and usually lasts only a short time, sometimes not more than 10 minutes. * * * It is in summer and autumn that the large dragon flies appear; not *with* the wind, but — and this is the most curious part of the matter — in advance of it; and in as much as these insects are not seen in the country at other times, and frequently appear in seasons of prolonged drought when all the marshes and water courses for many hundreds of miles are dry, they must of course traverse immense distances, flying before the wind at a speed of 70 or 80 miles an hour. On some occasions they appear almost simultaneously with the wind, going by like a flash and instantly disappearing from sight. You have scarcely time to see them before the wind strikes you. As a rule, however, they make their appearance from 5 to 15 minutes before the wind strikes; and when they are in great numbers the air, to a height of 10 or 12 feet above the surface of the ground, is all at once seen to be full of them, rushing past with extraordinary velocity in a northeasterly direction. In very oppressive weather, and when the swiftly advancing *pampero* brings no moving mountains of mingled cloud and dust and is consequently not expected, the sudden apparition of the dragon fly is a most welcome one, for then an immediate burst of cold weather is confidently looked for."

The author continues: "The mystery is that they should fly from the wind before it reaches them, and yet travel in the same direction with it. When they pass over the level, drier country, not one insect lags behind or permits the wind to overtake it; but, on arriving at a hut or large plantation they swarm into it, as if

seeking shelter from some swiftly pursuing enemy and on such occasions they sometimes remain clinging to the trees while the wind spends its force. This is particularly the case when the wind blows at a late hour of the day; then on the following morning, the dragon flies are seen clustered to the foliage in such numbers that many trees are covered with them, a large tree often appearing as if hung with curtains of some brown glistening material, too thick to show the green leaves beneath."

There is evidently some connection between climatic conditions and the hosts of dragon flies recorded above. It is interesting in this connection to note the record by Professor F. Wood-Jones (1912, p. 204-5) to the effect that dragon flies appear on the Cocos-Keeling islands in the Indian ocean after northerly winds, even though these be of short duration. It may be that the *pampero* of the Argentine and the northerly winds of the Indian ocean, as well as the aerial disturbances noted below, tend for one reason or another to drive the insects to shelter, and in the case of those flying over water, this means to rest upon the nearest available land, and on islands very considerable assemblages would naturally result.

On the evening of August 13, 1881, the air for miles around Fairbury, Livingston County, Ill., was reported by A. H. Mundt (1882, p. 56-57) as being literally alive with dragon flies between the hours of 5 and 7 o'clock from a foot above ground up as far as the eye could reach. The same was reported by other observers 12 to 15 miles east and west, the insects moving in a southwesterly course. The writer suggested the possibility of the Manitoba wave, then reported in the Chicago papers, having an influence on this flight or migration and on referring to the report (1883, p. 32) of the Chief Signal Officer there is a record of a low barometer area accompanied on the 11th by high wind velocities at a number of Great Lake stations, as for example Grand Haven, S. 28 miles, Marquette, S.W., 26 miles and at Escanaba and Milwaukee by velocities of over 25 miles. This was during a dry period, a time when dragon flies probably range far in the search for food. Howard (1901, p. 366) considers it probable that dragon fly migrations may be related to dry periods. It appears entirely possible that the marked wind velocities accompanying this storm might have brought about a condensation of the dragon fly fauna and that the conditions recorded by Mr Mundt may be somewhat similar to those recorded above for the more violent *pampero* of the Argentine.

The dragon fly fauna of the Hawaiian islands is interesting in this connection. Professor C. H. Kennedy of the Ohio State Uni-

versity informs us that there are about 30 species of Zygoptera which fall in one supergenus, Megalagrion, and probably represent a single early introduction. There are, in addition, four species of Anisoptera, he points out, three of which are identical with present-day continental forms.

In discussing with Professor Kennedy the possibility of there being any physical explanation why the larger, stronger-flying American dragon flies were unable to establish themselves earlier in the Hawaiian islands, he suggested that recent agricultural developments greatly increased the areas of ponds or still water inhabited by these dragon flies, whereas the more primitive Agrions or Megalagrions were mountain stream species. In search of additional information along this line, I submitted the problem practically as above to Professor J. F. Illingworth of Honolulu, who replied in a letter dated March 3, 1925, as follows:

I am greatly interested in Professor Kennedy's explanation of our dragon fly fauna. It certainly agrees with the known facts. Originally, of course, all the waters of the islands were confined to the narrow mountain streams. Hence the native dragon flies, of necessity, developed under such conditions, as they do at the present time. With the coming of the first natives, however, (perhaps 1200 years ago) cultivation probably began. The natives evidently brought taro plants with them in their small boats. The cultivation of this food plant requires that the waters of the mountain streams be spread out over wide areas and kept standing for months about the roots of the developing plants. Hence such conditions are perfect for the nymphal stages of our introduced dragon flies; they certainly flourish in the taro patches.

A letter dated March 13, 1925, from O. H. Swezey of Honolulu states in relation to the above that the extensive culture of rice and taro has resulted in great expanses of water in which dragon flies can breed, although they are not entirely dependent upon them, for even now *Anax junius* and *A. strenuus* breed in pools of the mountain streams, and Perkins states that *Nesogonia blackburni* breeds abundantly in temporary pools of the higher elevations caused by heavy rains. Furthermore, he adds, there are swampy areas with considerable pools both at higher elevations as well as on the lowlands of most of the islands, which have evidently been in existence long before the advent of man in that section, so there appears to have been plenty of opportunity for pond-inhabiting dragon flies to become established before the Hawaiian islands were peopled. He further suggests that the reason for the large number of species of Zygoptera in the Hawaiian islands,

as compared to the relatively few Anisoptera, is that the former are local in habit, a condition favorable for differentiation, whereas the latter are strong flyers and have remained generally distributed throughout the islands.

It is impossible to estimate the percentage of pond areas favorable for the establishment of migrant, presumably nearly exhausted dragon flies. The extremely long trip necessary for an introduction would presumably make such occurrences very rare and furthermore there is a possibility, if not probability, that many smaller insects suitable as food for the larger dragon flies may have been relatively scarce earlier, these factors all working against successful establishment of migrants.

The flight possibilities of dragon flies is illustrated by the following: *Pantala flavescens* Fabr., widely distributed in the United States and temperate and tropical Asia, Africa and America, occurs in the Hawaiian islands, though not in Europe. April 11, 1896, numerous dragon flies of this species appeared at 11 o'clock at night in a heavy rain with a moderate easterly wind on the P. and O. steamer "Victoria" in the Indian ocean, the nearest land being the Keeling islands, north 20, west 290 miles and northwest of Australia, south 70, east 900 miles (McLachlan, 1896, p. 254). It is quite possible, in view of the record by Professor F. Wood-Jones to the effect that dragon flies appear on the Cocos-Keeling islands in the Indian ocean after northerly winds, that such currents also carried these insects farther south and hence they may have been Asiatic in origin, though there is a possibility that they may have drifted from the Australian continent nearly 1000 miles distant, since Bartholomew's Atlas of Meteorology indicates southeast winds prevailing in that section of the world during the month of April. The distribution of this insect suggests ability to remain in the air for considerable periods.

Another Hawaiian species, *Tramea lacerata* Hag., has been recorded from widely separated localities in the United States and Mexico. A third species, *Anax junius* Drury, occurs throughout much of North America, the West Indies, Bermudas, Hawaiian islands, Tahiti, Kamchatcha and China, the distribution again suggesting ability to remain in the air for considerable periods. Professor Kennedy states that representatives of the three genera mentioned above are the highest and ablest flyers we have and that they seldom alight.

If the above-mentioned species of Anisoptera are carried by the winds and have become established in the Hawaiian islands during

recent years, there should be some physical explanation. Professor C. H. Kennedy suggests that the topography of the volcanic Hawaiian islands was such that there were probably no ponds in the islands before the advent of man. The later arrivals among the Odonata are all pond species so far as known. The natives constructed extensive fish ponds and later rice fields, both of which are full of these pond species. This at least increased the pond areas and may explain why these dragon flies were able to establish themselves in the islands. The earlier established Zygoptera, Megalagrion are mountain stream species and therefore would find suitable conditions even in prehistoric times. There is also a possibility that the endemic fauna had too few small diptera in particular to support the larger dragon flies.

The following is an excerpt from a recent letter from Dr R. Heber Howe, a close student of dragon flies:

Personally, I have observed for many years the swarming of species, particularly *Anax* and *Libellula pulchella*, and their migrations down the coast in September. I have noted these migrations from Maine to New Jersey and they were not only frequently but generally, if not always, against the prevailing southwest wind. These continuous streams of moving insects do not rise as birds in search of favorable air strata. At Sakonnet Point, Rhode Island, I have counted during one hour over 1200 insects, including not only the above species but *Tramea carolina* and *Aeshna* species in sufficient numbers to convince me absolutely of it being a migratory rather than a sporadic pushing along, due to local causes such as wind movement and the like. They are frequently accompanied by the monarch butterfly which, I believe, has been proved to migrate, and specimens of *Anax* sent me from the south collected in October are invariably tattered and torn, and would appear to be flies that had migrated. There are several spring records, one I recorded only a year ago. I feel very certain in my own mind that the perfect correlation of the action of insects under migration with those of birds leaves little doubt that the two phenomena are alike, and probably the result of the same cause, i. e., the ice advance in the glacial period.

Practically the same statements appear in the Proceedings of the Boston Society of Natural History (Shannon 1921, p. 111). He also gives some interesting data along the same line in the American Museum Journal (1917, p. 33-40).

Swarming and an assumed migration of several species of the larger dragon flies have been recorded by F. M. Root (1912, p. 209), who observed a number of species on Pelee Island, Ontario, Canada, near the western extremity of Lake Erie about the middle of August

in 1910 and again in 1911. In the latter case there were many general *Anax junius* Drury. The abundance of dragon flies in 1911 followed the appearance of numerous deer-flies and Mr Root suggests a possible connection. Two other dragon flies, *Aeschna constricta* Say and *Tramea lacerata* Hagen, presumably winter in the upper Adirondacks and would therefore not be compelled to migrate on account of the rigors of the cold season about western Lake Erie.

There are some general considerations which should be taken into account in connection with the above-noted dragon fly movements. In the first place, the nymphs of four species, *Aeschna constricta* Say, *Anax junius* Drury, *Tramea lacerata* Hagen, and *Libellula pulchella* Drury have all been obtained in the Adirondacks, at Saranac Inn or its vicinity, a typical boreal region. The occurrence of the immature stages of *Aeschna constricta* Say in that section is almost conclusive evidence that the insect winters successfully under severe climatic conditions, since it has a life cycle of at least two years. *Anax junius* has a larval period of less than three months and this is probably true of *Tramea lacerata* and *Libellula pulchella*. I should expect to find all these species in the Adirondacks in ponds which did not freeze solid (C. H. Kennedy *in litt.*). The comparative abundance of some of these species suggests that hibernation may be true of others. This being so, there is no such reason for a southern migration as in the case of an admittedly tropical or subtropical insect like the monarch butterfly.

It is well known that dragon flies are predacious, and during dry periods at least adults are found long distances from suitable breeding places, presumably coursing over considerable areas as a result of the reduced food supply. The dry periods of midsummer and fall, supplemented by the cooler temperatures prevailing toward the end of the season, would all combine to reduce the number of small insects upon which dragon flies feed, and these conditions alone would account for a general southward drift. Even if they were not affected to some extent by favorable winds and at times by storms, it would be very easy for combinations of these factors to bring about such occasional flights of dragon flies and in the fall at least the tendency would more likely be southerly than in any other direction.

Assuming that individual dragon flies, issuing from nymphs in northern areas, successfully made their way to warmer sections where they were able to winter — which by the way has not been established — the conditions obtaining in the spring would be such

that either overwintering individuals or those developing in early spring would very likely follow northward the appearance of somewhat abundant food which accompanies the advance of spring. The incentive toward northern flight would in this respect be practically identical with that of many birds. Even restricted movements northward might easily lead to the conclusion that there was a general dragon fly migration, whereas investigations may prove that normally this is but a series of minor migrations, the insects in different latitudes covering relatively short distances, although the sequences might lead one to infer that these movements represented a general migration. Systematic observations, supplemented by marking considerable numbers of insects, should result in obtaining some conclusive data.

The marked periodicity in the appearance of midges and mosquitoes and the somewhat close restriction of these insects to marshy areas should also be taken into account in considering dragon fly movements. Judging from the behavior of birds, it is fair to assume that the swift flying dragon flies would naturally concentrate in areas where there was an abundance of food, and in the case of those species developing in an aquatic environment there is no question as to the great fluctuations in the abundance of the adults. When the small flies have mostly dispersed in such areas, general movements in the search of better feeding grounds would naturally be expected. This alone might readily explain some of the supposed migrations, and such movements, even if of no great extent, would be largely seasonal.

Orthoptera

Locust or Grasshopper Movements. These are so general and well known that a summary of available information is sufficient. The reports of the United States Entomological Commission contain a vast fund of information in regard to the Rocky mountain locust and also much of value in relation to most of the more destructive species found in other parts of the world. The general deductions formulated by Packard and Thomas are extremely interesting. They state that *Melanoplus spretus* Uhl. seldom migrates except when the air is in motion and that as a rule the insects depend almost wholly upon the wind, simply using their wings to sustain themselves and generally heading into the wind and drifting backwards. In light winds they usually head with the wind and use their wings to accelerate their movements. The authors cite data to show that locusts may attain considerable heights, possibly two miles,

frequently flying to such a height as to be out of sight, that their flights may be continued for several days over a distance of several hundred miles and that they often fly at night. Furthermore, they state that a sudden change of wind or temperature or an increase in moisture usually brings down flying swarms and that timber belts have a tendency to obstruct their movements and to limit their migration. This last is possibly explainable in part by the lower temperatures and greater moisture usually prevailing over timbered areas. An examination of a map showing the permanent breeding grounds of this insect and the areas invaded indicates usually a southeasterly flight, that is, drifting with a northwesterly wind, the distance covered being at least 1000 miles or more. It is the writer's opinion that the velocity of movement and the distances covered were greatly underestimated, probably because the figures were based largely upon surface velocities which are manifestly much too low for insects or winds at some altitude above the surface. It also seems probable that the altitude two miles is excessive, though not impossible.

Observations by Corkins (Can. Ent., 1922, 54:1-4) in North Dakota indicate that the grasshoppers take flight in a stiff breeze, the rate of flight near the ground being approximated at 20 miles an hour and the thickest part of the swarm from 500 to 800 feet high, the maximum altitude being 1650 feet above the ground.

The movements of the Rocky mountain locust agree very well with those of Old World species. Scudder cites a well-authenticated case of a swarm of grasshoppers occurring at sea 1200 miles from the nearest land. In the case of the locust devastations on the island of Teneriffe in 1649, the insects were seen coming from the direction of Africa some 200 miles distant. These two suggest most strongly that insects are capable of maintaining themselves in the air for hours and presumably drifting with considerable velocity, although there is a record of their alighting upon the water and apparently remaining over night. This latter is possible and may be more general among insects than has been suspected, although there is nothing in view of the rapid drifting mentioned above to necessitate a rest if the insects possess only a moderate ability to sustain themselves in the air.

The early studies of the Rocky mountain locust demonstrated not only a movement into new feeding grounds but also a return, and through this Packard and Thomas were able to satisfy themselves that migrations over a distance of at least 1000 miles occurred, the return generally being toward the permanent breeding ground.

The large, widely distributed *Schistocerca tartarica* Linn., with a length of four inches, may drift long distances. There is a record by Willis E. Hurd (1917, p. 11) of a swarm of these notorious wanderers in latitude $20^{\circ} 57'$ N., longitude $39^{\circ} 28'$ W., some 1200 miles from the African coast, evidently having drifted on an east-northeast wind. It has been taken far out at sea on other occasions.

Even cockroaches may react to the migratory instinct. Howard (1895, p. 349) records large numbers of the croton bug, *Blattella germanica* Linn., issuing from the rear of an old restaurant fronting upon Pennsylvania avenue, Washington, D. C., and moving across a muddy street undeterred by pools of water, etc. The march continued for two or three hours, many thousands crossing and nearly all being females.

SUMMARY

The foregoing demonstrates that winds, especially those of the upper air, are ample to account for the occasional and possibly somewhat general extended movements of insects. There is no necessity for limiting such movements to species possessing superior flying ability since the probabilities are that the purposive flight of an insect — the distance covered by its own efforts — is relatively insignificant. The fact that most of the extended drifts or flights of insects are recorded for the larger, presumably stronger-flying forms by no means invalidates the above since it is only the larger forms which would ordinarily attract notice. The occurrence of a Trichopteron, a Microlepidopteron and a plume moth, all small, relatively inefficient flyers, on the Kentish Knock Lightship 21 miles from the nearest land suggests the possibilities in this direction. The same condition is true for the Rebecca Shoal Light Station with the occurrence there of such inefficient flyers as a lacewing, a damsel fly and fragile gnats. A similar condition over a wide stretch of water is shown by the observations of Doctor McAtee. Ordinarily the small insects would be overlooked and consequently an absence of record is not necessarily significant.

The very general distribution of certain small midges and also of spiders mentioned above is at least presumptive evidence that some of these small forms are carried as great distances as is the case with larger insects.

The causes leading to general movements of insects are worthy of consideration. In the case of a number of aphids with alternate food plants, it is usually assumed by entomologists that migration follows overcrowding and is a decided advantage to the species in

that numerous parasites and other natural enemies are left behind. There appears to be among insects a somewhat definite reaction whenever crowding occurs and it may be that this intolerance in the case of thousands or millions of adult butterflies or other insects in a restricted area results in a greater readiness to yield themselves to air currents, and as a consequence there may be extended drifting. This may explain the movements of the cotton moth, the monarch butterfly and a number of other free-flying forms when so abundant as to be too close together for comfort. The effect of crowded conditions is also seen in the swarms leaving the nests of bees and ants, though here there may be another influence, namely, a more or less determinate sexual reaction. This latter, except as it may excite to unusual activity, however, has little part in the drifting of swarms of Trichoptera or "sand flies" and May flies from the vicinity of rushing waters to the heart of nearby cities, a very common occurrence, which may perhaps be explained best as a blind reaction to overcrowding rather than a deliberate attempt at migration.

The presence of a few individuals at great distances from their normal habitat may be readily explained as due possibly to the dispersive effect of wind currents dropping a few at long distances from the mass, or it may be that occasional individuals when in the normal habitat fail to keep near enough to earth and allow themselves to be carried by air currents.

The numerous water-swept insects along the littoral and others in deserts is conclusive evidence, taken in connection with the data obtained from lighthouse keepers and observers upon ships, that many insects are relatively free-flyers. There must be an appreciable aerial insect population. Air transportation varies considerably, it being much greater when species reacting to some impulse fly or allow themselves to drift in large numbers. More quantitative studies of lake drift in particular would make possible rather accurate estimates of the numbers of insects generally occurring in the air. Somewhat the same type of data may be secured by collections upon glaciers or mountain tops.

There is no question that there are marked annual movements or seasonal migrations north and possibly south, the latter by no means proved, by the monarch butterfly. The same is stated to be true of dragon flies, although there is even less evidence. Certain insects appear to approximate the seasonal movements of birds, although it has not been established that in the case of either butterflies or dragon flies, individuals make most of the trip either north or south or that individuals moving south in the autumn survive

and migrate northward in the spring. No available data indicate this to be impossible or even improbable. On the other hand, this movement may be a migration of species rather than of individuals. Even here it may be a more or less unintelligent reaction to prevailing air currents and other natural agencies rather than a purposive north and south migration. The instinctive following of a leader, once movement has been established from a densely populated area, may explain many supposed migrations.

The movements or migrations of the monarch and dragon flies suggest that something of the kind may obtain in the case of other insects. This is most probably true. The activities of the larger forms are more easily noted and, correctly interpreted, should lead to sound conclusions in the case of the less abundant species.

BIBLIOGRAPHY

Adkin, Robert

1925 Dispersal of Butterflies and Other Insects. *Nature*, Sept. 26, p. 467

Anon.

1925 Apicultural Notes. *Jour. Econ. Ent.*, p. 437

Ball, S. C.

1918 Migration of Insects to Rebecca Shoal Light Station in the Tortugas Islands. Carnegie Institution of Washington, Department of Marine Biology, v. 12, no. 10, p. 193-212

Bartholomew, J. G. & Herbertston, A. J.

1899 Winds over the Ocean. *Atlas of Meteorology*, plate 14

Borner, L.

1922 Ueber Fernfluge von Blattlausen nach Beobachtungen auf Memmert und Helgoland. *Vehr. Deutsch Ges. angew. Ent.* 3 Mitgliederversammlung zu Eissnach 28 bis 30 Sept. 1921, p. 27-35. Berlin

Britton, W. E.

1919 Swarms of Aphids. 19th Report of the State Entomologist, Conn. *Agric. Ex. Stat. Bul.* 218, p. 203

Caffrey, D. J. & Worthley, L. H.

1927 Progress Report, U. S. Dep't Agric., *Dep't Bul.* 1476, p. 1-155

Chief Signal Officer

1883 List of State Weather Services from Which Meteorological Reports Have been Received at the Office of the Chief Signal Officer for the Year Ending June 30, 1883. Report of the Secretary of War. *Chief Signal Officer*, v. 4, pt 2, p. 32-34

Clark, Austin

1925 *Animals of Land and Sea*, p. 1-276

Clarke, William Eagle

1903 *Vanessa Cardui and Other Insects at the Kentish Knock Lightship.* *Ent. Mon. Mag.*, 2d ser., v. 14:289-90

Collenette, C. L.

1925 A Noctuid Moth in Mid-Pacific. *Ent. Mon. Mag.* 6:206

Cotterell, G. S.

1925 The Hispid-Leaf Miner of Oil Palms on the Gold Coast. *Bul. Ent. Research*, 16:77-83

Dammerman, K. W.

- 1922 The Fauna of Krakatau, Verlaten Island and Sebesy. *Treubia*, v. 3, p. 61-112

Darwin, Charles

- 1882 *Journal of Researches into the Natural History and Geology of the Countries Visited During the Voyage of H. M. S. Beagle Around the World*, p. 1-519

DeLong, D. M.

- 1923 Distribution of Leaf Hoppers. *Ent. Soc. Amer. Ann.*, 16:363-70

Elton, C. S.

- 1925 The Dispersal of Insects to Spitzbergen. *Ent. Soc. Lond. Trans.*, p. 289-99

Fernald, H. T.

- 1925 Rapidity of Flight of a Dragonfly. *Econ. Ent. Jour.*, 18:638

Fletcher, Robert K.

- 1926 Notes on a Migration of the Snout Butterfly, (Lepidoptera, Libytheidae). *Ent. News*, 37:106-7

Fletcher, T. Bainbrigge

- 1910 Lepidoptera, exclusive of the Tortricidae and Tineidae, with Some Remarks on the Distribution and Means of Dispersal amongst the Islands of the Indian Ocean. *Linn. Soc. Lond. Trans. 2d ser., Zool.*, 13:265-323
1921 *Proc. 4th Ann. Ent. Meeting at Pusa, India*, p. 212-13

Forbes, Henry O.

- 1885 *A Naturalist's Wanderings in the Eastern Archipalego*, p. 1-536

Grote, A. R.

- 1874 On the Cotton Worm of the Southern States. *Amer. Nat.* 8:722-27

Gurney, W. B. & Woodhill, A. R.

- 1926 Investigations on Sheep Blowflies. *Dep't Agr. N. S. W., Sci. Bul.* 27, p. 1-28

Hayward, Kenneth J.

- 1925 Migration of Butterflies. *Entomologist*, 58:147-49

Hingston, R. W. G.

- 1925a *Nature at the Desert's Edge*, p. 1-299
1925b *Animal Life at High Altitudes*. *Ann. Rep't Smith. Institution*, p. 337-47

Howard, L. O.

- 1895 A Migration of Cockroaches. *Insect Life*, v. 7, p. 349
1901 *The Insect Book*, p. 1-429

Hudson, G. V.

- 1905 Notes on Insect Swarms on Mountain Tops in New Zealand. *New Zealand Institute Trans.*, 38:334-36

Hudson, W. H.

- 1892 *The Naturalist in La Plata*, p. 1-388

Humboldt, Alexander Von

- 1850 *Views of Nature, Translation*. *Lond.* p. 1-469

Hurd, Willis E.

- 1917 Grasshoppers at Sea. *Mon. Weather Rev. (U. S.)* p. 11
1920 Influence of the Wind upon the Movements of Insects. *Mon. Weather Rev. (U. S.)* p. 94-98
1922 Dust over the North Atlantic. *Mon. Weather Rev. (U. S.)* 50, p. 301

Johnston, H. B.

- 1925 *Heliothrips indicus* (Bagnall) Injurious to Man in the Sudan. Ent. Mon. Mag., 61:132-33

Jones, F. Wood

- 1912 Corals and Atolls, p. 1-309. London

Kellogg, V. L.

- 1904 [Gregarious Hibernation of Certain Californian Insects] Ent. Soc. Lond. Proc., p. 22-27

Leman, G. C.

- 1925 Coccinellidae and Vesuvius. Ent. Record and Jour. Var., 37:143

Lugger, Otto

- 1889 On the Migrations of the Milkweed Butterfly. Wash. Ent. Soc. Proc., 1:256-58

Lutz, F. E.

- 1918 Field Book of Insects. Putnam's. p. 1-509

Maxon, Asa C.

- 1918 Some Factors Influencing the Distribution of *Pemphigus betae* Doane in Beet Fields. Jour. Econ. Ent., 11:231-36

McAtee, W. L.

- 1915 A Remarkable Flight of Caddis Flies and Chironomids. Science, 42:694-95

McGregor, E. A.

- 1924 Painted Lady Butterfly (*Vanessa cardui*). The Insect Pest Survey Bul., v. 4, no. 3, June 1, p. 70-71

McLachlan, Robert

- 1884 On the Sub-aquatic Habits of the Imago of *Stenopsylla*, A Genus of Trichoptera. Ent. Mon. Mag., 21:234-35

- 1896 Oceanic Migration of a Nearly Cosmopolitan Dragon-Fly (*Pantala flavesens* F.) Ent. Mon. Mag., 32:254

- 1900 Abstract of an Article by Mons. A. Lancaster, Migration of *Libellula quadrimaculata* in Belgium in June 1900. Ent. Mon. Mag., 36:222-26

Muir, F.

- 1921 Some Problems in Hawaiian Entomology. Proc. First Pan-Pacific Sci. Conf., p. 161

Muller, Albert

- 1871 The Dispersal of Non-migratory Insects by Atmospheric Agencies. Transactions Ent. Soc. London, p. 175-86

Mundt, A. H.

- 1882 Migration of Dragon-Flies (*Aeshna heros* Fabr.) Can. Ent., 14:56-57

Needham, James G.

- 1900 Insect Drift on the Shores of Lake Michigan. Occas. Mem. Ent. Soc. Chicago, v. 1, p. 19-28

Osburn, R. C.

- 1916 A Migratory Flight of Dragonflies. Jour. N. Y. Ent. Soc., 24:90-94

Peirson, H. B.

- 1921 Life History and Control of Pales Weevil, Migration. Harvard Forest Bul., no. 3, p. 16-17

Perkins, R. C. L.

- 1913 Distribution of Animals by Natural Agencies. Fauna Hawaiiensis, v. 1, p. xlvi-xlviii.

- Piper, C. V.**
1897 A Remarkable Sembling Habit of *Coccinella transversoguttata*. Ent. News, 8:49-51
- Poulton, E. B.**
1904 [Gregarious Hibernation of Certain Californian Insects] Entomological Soc. Lond. Proc., p. 24-25
- Root, F. M.**
1912 Dragon Flies Collected at Point Pelee and Pelee Island, Ontario, in the Summers of 1910 and 1911. Can. Ent., 44:208-9
- Schwarz, E. A.**
1890 Notes on the Comparative Vitality of Insects in Cold Water. Ent. Soc. Wash. Proc., 1:208-15
- Scott, Hugh**
1926 Coleoptera, Sawflies and Tipulidae Drowned in the Sea. Ent. Mon. Mag., 62:165-69
- Scudder, S. H.**
1889 The Butterflies of the Eastern United States and Canada, v. 1, p. 1-766
- Shannon, Howard J.**
1917 Autumn Migrations of Butterflies. Amer. Museum Jour., Jan., p. 33-40
1921 Migration. Proc. Bost. Soc. Nat. Hist., 36:111
- Skertchley, S. B. J.**
1879 Butterfly Swarms. Nature, 20:266
- Snow, Laetitia M.**
1902 The Microcosm of the Drift Line. Amer. Nat., 36:855-64
- South, Richard**
1885 Insect Migration. Ent. Mon. Mag., 21:208-11
- Stackman, E. C.**
1923 Spores of the Upper Air. Jour. Agric. Research, 24:599-605
- Swezey, O. H.**
1921 Some Aspects of Hawaiian Entomology, Proc. First Pan-Pacific Sci. Conf., p. 172-74
- Thorncroft, T.**
1865 The "Blown-over" Theory. Entomologist, 2: 289-90
- Townsend, C. H. T.**
1917 Head and Throat Bots. N. Y. Ent. Soc. Jour., 25:98-105
1926 Around the World in a Daylight Day. A Problem in Flight. Scien. Mon., 22:309-11
- Tutt, J. W.**
1899 Migration and Dispersal of Insects (Odonata). Ent. Record, 11:181-83
1900a No Title. Ent. Record and Jour. of Var., 12:253-58
1900b No Title. Ent. Record and Jour. of Var., 12:13-16
1901 Migration and Dispersal of Insects: Coleoptera. Ent. Record, 13:353-55
1902 Migration and Dispersal of Insects. Final Considerations. Ent. Record, 14:292-95
- Van Leeuwen, W. Docters**
1920 The Galls of Krakatau and Verlaten Eiland (Desert Island). Ann. Jard. Bot. Buitenzorg, 31:57-82

Visher, S. S.

- 1925 Tropical Cyclones and the Dispersal of Life from Island to Island in the Pacific. Amer. Nat., 59:70-80

Walker, J. J.

- 1914 The Geographical Distribution of (*Danaida plexippus* F.) with Especial Reference to Its Recent Migrations. Ent. Mon. Mag., 25: 185-94, 224-37

Watson, F. E. & Coleman, L. V.

- 1912 *Iphiclides ajax* and *Eurymus interior* (Lepid.) from the Summit of Mount Marcy, N. Y. Brooklyn Ent. Soc. Bul. 8, p. 4-6

Webster, F. M.

- 1902 Winds and Storms as Agents in the Diffusion of Insects. Amer. Nat., 36:795-801

Weiss, H. B.

- 1927 Insects Captured in the Lookout Stations of New Jersey. Bureau of Statistics and Inspection, N. J. Dep't Agric., Circular 106, p. 1-21

Wheeler, William M.

- 1910 Ants, p. 1-663

Williams, C. B.

- 1919 Migration of Yellow Butterflies. Ent. Soc. London Trans., 67:78-88
1923 Records and Problems of Insect Migration. Ent. Soc. Lond., Trans., 71:207-33
1925 The Migrations of the Painted Lady Butterfly. Nature, 115:535-37
1926 Voluntary or Involuntary Migration of Butterflies. Entomologist, 59:281-88

THREE JAPANESE BEETLES NEW TO NEW YORK STATE

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There has been a remarkable development in the southeastern portion of New York State.

Two Japanese beetles were found or recognized for the first time in this area during the summer of 1926 and this was followed by the discovery later of a number of infestations by the much better known Japanese beetle, *Popillia japonica* Newm., a destructive insect which has been known for a decade in portions of New Jersey. This last is much more destructive to foliage at least and probably to sod lands than the other two. The beetles of the latter feed to a relatively small degree upon foliage, although the grubs are very destructive to sod and those of both species have caused appreciable injury to lawns in the infested area. The three are somewhat closely related and have so much in common that accounts of all have been included in this general paper.

JAPANESE BEETLE

Popillia japonica Newm.

Five counties, Nassau, Queens, Kings, Richmond and New York, and a part of a sixth, Westchester, are under drastic regulations because the Japanese beetle was found last summer somewhat abundantly, and widely distributed over this area. These quarantine restrictions prohibit the movement to points outside the restricted area of green, sweet or sugar corn, peas and beans in the pod, cabbage, parsley, carrots with tops, beets with tops, onions with tops, lettuce, out-door grown flowers, hay, straw, unthreshed grains and forage crops, between June 15th and October 15th without inspection and certification, and furthermore provide for an embargo upon shipments from freight yards and markets when large numbers of beetles are on the wing and there is an unusual risk of spreading the insect. There are also restrictions on the shipments of sand, soil, earth, peat, compost and manure to points outside the regulated area and there are requirements respecting the cleaning of cars and other vehicles passing the quarantine line. There are in addition drastic regulations in relation to the transportation of nursery and ornamental stock.

The conditions outlined above are bound to arouse a very considerable amount of interest in this small greenish beetle, only about three-eighths of an inch long and most easily recognized by the shining greenish color of the head and thorax, the coppery brown tinged with green of the strongly ridged wing covers and the series of whitish spots usually showing around the edge of the posterior extremities of the wing covers. This insect, a native of Japan, was discovered near Riverton, N. J., in 1916. The destructive nature of the beetle was recognized early and the state of New Jersey in cooperation with the Federal Department of Agriculture has endeavored in every practical manner to prevent its spread. Through careful and long continued study the authorities have ascertained the habits of the insect and the possibilities of control and in addition have spent considerable sums in introducing and establishing parasites which eventually may become important factors in keeping this insect somewhat within bounds.

History in this Country

The infested area in 1916 was estimated to be less than one square mile. It more than doubled the next year and the following year included nearly seven square miles. In 1919 it was found over more than 48 square miles, and in 1920 it had crossed the Pennsylvania line, increasing the total infested area to 114 square miles. This was further increased in 1921 to 270 square miles and in 1922 to 773 square miles. The following year, 1923, there were 1744 square miles infested.

The infested area then included many New Jersey townships, a number of Pennsylvania townships and one in Delaware. The following year there were additional extensions in these three states.

The spread this year, as determined by scouting, is at least 50 miles beyond that known in 1925. The infested territory included the southwestern corner of Connecticut, southeastern New York, southeastern Pennsylvania, a portion of Delaware and all of New Jersey, and comprises some 10,000 square miles.

Japanese beetles fly readily and take to the air when disturbed in much the same way as bees. Consequently the limits of flight or drift can be approximated only. It is well recognized that beetles may be carried with produce and in vehicles, especially automobiles, and while such movement may be regulated to some extent, an impassable barrier is out of the question. Moreover, the grubs are easily carried in soil about the roots of plants or even in soil without roots, this latter accounting for the stringent regulation in relation

to the shipment of nursery stock, soil etc. outside the infested area. The best that can be done is to check distribution, and judging from the history of the insect in this country, very considerable extension of the infested area may be expected from year to year.

It should be remembered the probabilities favor spread from thickly infested areas rather than from the outside sparsely infested sections. Consequently the actual distance covered by the insect in its movements may be considerably greater than that indicated by the average extension of the infested areas.

Quarantined Area in New York State

The fifth revision of quarantine no. 48, effective on and after October 11, 1926, limits the regulated area in New York State and Connecticut as follows:

From the southern shore of Long Island, north along the Nassau-Suffolk county line to Long Island Sound; across Long Island Sound to the Connecticut shore, following the eastern boundary of Stamford township, Conn., to the New York State line; thence along the New York State line north to the northern boundary line of the township of Lewisboro; west on this township line to the Croton river; down the Croton river to the Hudson river, south on the Hudson river to the New York-New Jersey state line.

The regulated area in New Jersey extends from this point northwest on the New York-New Jersey line to the Delaware river near Port Jervis, N. Y. This latter indicates that another and considerable proportion of New York State is adjacent to the regulated area.

Means of Dispersal

The Japanese beetles are strong fliers, and are particularly active during hot days. They fly from tree to tree and from one place to another in search of suitable food. Individual beetles have been followed in New Jersey for more than one-half a mile.

This tendency to fly considerable distances is more marked the latter part of July and in August than during the earlier period when the insects are upon the wing. The rate of spread has been approximately from 10 to 15 miles each season except in 1926 as pointed out above. It is believed that flight is one of the important factors in the dispersal of these pests, and with the records of the beetles swarming occasionally in cities, it is quite possible that considerable greater distances are covered in individual flight than indicated by the above figures. In addition, streams undoubtedly are responsible for considerable spread by drifting.

Artificial agencies are by no means unimportant. Japanese beetles are strongly attracted to green corn and it is easy for them to become established in the tip and transported long distances. There is also danger of the beetle being carried with other produce. These possibilities are the basis for the rigid restrictions in relation to the shipment of certain garden produce during the period the beetles are in flight, namely from about June 15th to October 15th.

The ready flight of the beetle results in its entering vehicles traversing the badly infested area, and although many may leave shortly, there is always a chance that one or more may lodge in the corner of a cushion or some protective shelter and be transported very considerable distances.

It is difficult to determine the relative efficiency of these various means of dispersal. It appears quite probable that flight or drifting with the wind is an important factor, perhaps the most important, although the danger of the insects being transported with produce and by vehicles etc. can not be ignored.

The occurrence of the grubs in the soil and their ability to subsist upon decaying organic matter as well as upon living roots make it relatively easy for the immature stages to be transported in the soil about the roots of plants and in shipments of manure or other vegetable matter from sections where the insect is somewhat well established. These conditions explain the restrictions imposed upon the shipments of nursery stock and soil from infested areas.

Food Habits and Abundance

The beetles display a marked preference for early apple and peach, sweet cherry, plum, grape, blackberry, linden, birch, oak, elm, horse-chestnut, willow and rose, although they have been recorded as feeding upon some two hundred different species of plants (see figs. 24-29).

A bad infestation by Japanese beetles is comparable in a general way to outbreaks by the well-known rose beetle, except that in the case of the latter there are much greater restrictions as to the character of the soil and the varieties of plants which may be affected. Only occasionally does the rose beetle become so extremely numerous as does the Japanese beetle in the worst infested sections, for example, about one and one-third gallons of beetles have been taken from each of 156 ten-year-old peach trees and 24 hours later the trees were about as heavily infested. The insects cluster upon the fruit and as many as 278 beetles have been collected on a single apple.

Japanese beetles have a somewhat characteristic method of feeding. They skeletonize the foliage. When the leaves are severely eaten they turn brown so that affected trees from a distance bear much the same appearance as New York orchards which have been severely attacked by canker worm. Like the rose beetle this insect also attacks the fruit, the early ripening varieties being severely injured and almost all the epidermis and the pulp being eaten away on badly infested trees.

Since grubs of the Japanese beetle feed upon the roots of grasses, many lawns have been badly damaged (figures 31, 32). There have been as many as 1531 grubs found in a measured square yard of lawn, and as many as 717 in a square yard of pasture land. There are records of serious injury to the roots of strawberry plants, beans and other vegetable crops and ornamental plants. The damage is roughly proportional to the abundance of the insects.

Life History and Habits

The life cycle of this pest is completed in a year, most of which is spent in the soil as an egg, grub and pupa, although the beetles are above ground from the latter part of June until early in October. The beetles feed for several days to a week before egg-laying begins. The eggs are usually deposited in uncultivated places, such as grasses, fields, or weedy areas along roadways, the moist places in swampy ground and in soil containing humus. Each beetle deposits from 30 to 60 eggs. Young grubs hatch some two weeks later and feed on decaying matter in the soil and on live plant roots. Late in the fall they form earthen cells one and one-half to 12 inches below the surface, in which they pass the winter. The nearly full-grown grubs ascend to near the surface in early spring, late March or early April, and resume feeding. The older grubs complete their growth by early June and transform in earthen cells to the pupa and then two weeks later to the adult (see fig. 30).

Description

The adult is a beautiful insect about the size of a potato bug, namely about three-eighths of an inch long but more slender. The head and thorax are a shining brownish green and the elytra or wing covers are brown tinged with green at the edges. There are conspicuous whitish spots, usually not concealed, on the sides and at the tip of the abdomen. These latter afford a ready means of distinguishing between this and other similarly colored native beetles.

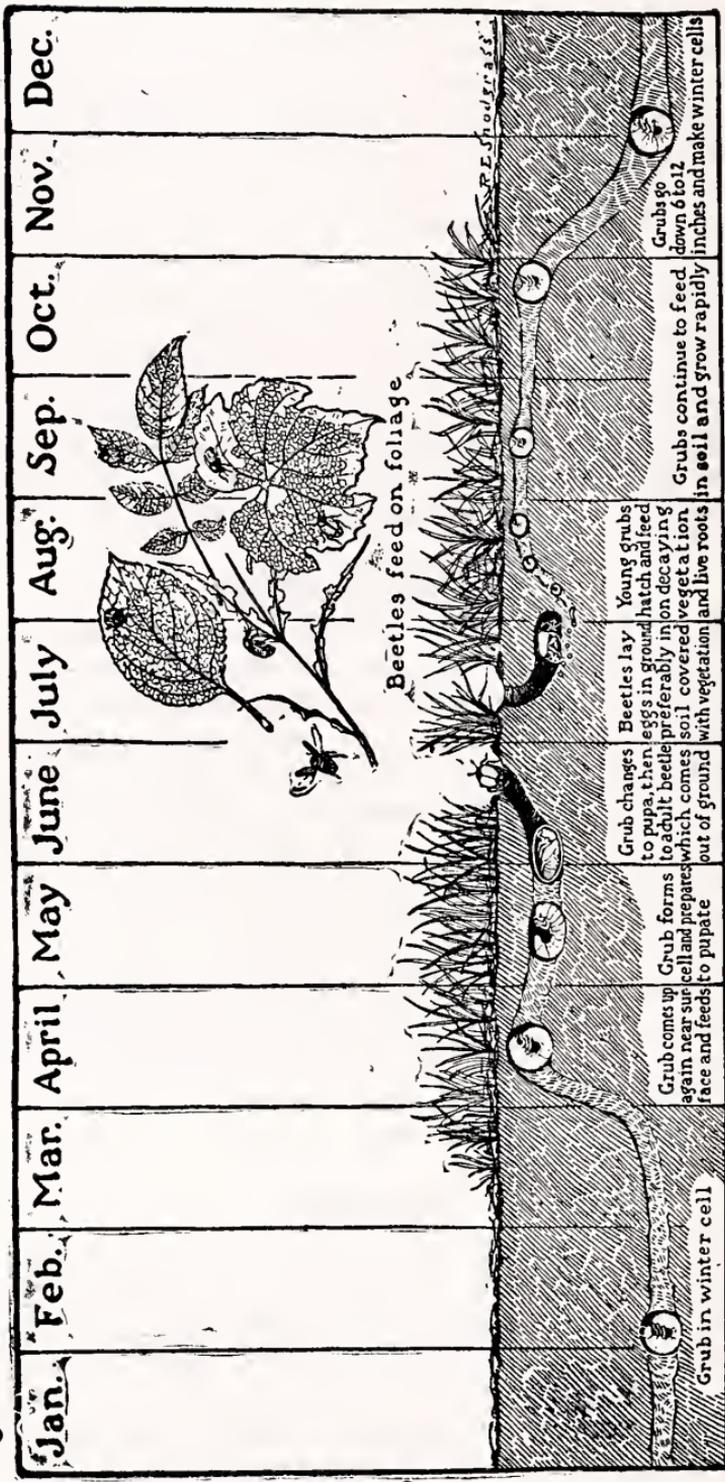


Figure 30 Diagrammatic illustration of the life cycle of the Japanese beetle and illustrating methods which may be used to destroy the different stages of the insect. (After Hadley, N. J. Dep't Agric. Circ. 36).

The eggs are milky white and measure about one-twenty-fourth by one-sixteenth of an inch.

The grubs range in size from tiny recently hatched individuals to those nearly an inch long when full grown. They are white with a more or less conspicuous bluish or blackish cast, especially at the posterior end, and the head is reddish brown. These grubs closely resemble our native white grub of the field, though they are much smaller (see figs. 31, 32).

The pupa is a pale tan color generally resembling in shape the beetle which is to appear later.

Natural Enemies

Since the Japanese beetle is not an important pest in its native country it is evident that some causes, possibly climatic assisted by various natural enemies, keep it from becoming destructive.

The probable value of natural enemies was so great that the Government has been systematically importing and attempting to establish in the New Jersey area a number of parasitic insects and predators native to Japan. It is quite possible that one or more of these may prove important in controlling this pest, although the work has not progressed far enough to permit any positive statements.

Birds appear to be the most important natural enemies native to the United States. The purple grackle or crow blackbird, the starling, the king bird, and cardinal are all common wherever the beetle is abundant and remains of this insect have been found in the stomachs of several. The meadow lark and catbird also feed upon Japanese beetles. The English sparrow and several other birds have also been recorded as feeding upon Japanese beetles.

Control Measures

Experience in the badly infested areas shows that one spraying with poison the latter part of June and early in July with three pounds of arsenate of lead and two pounds of flour to 50 gallons of water affords excellent protection if the insecticide is not washed off by rains. Otherwise it may be necessary to repeat the treatment. The commercial orchardist has little to fear from this insect, although it may be necessary to make some adjustments in his spraying schedules. It is necessary to spray apple trees before infestation in order to protect foliage and fruit and in New Jersey this should be not later than June 25th. Carman peaches or fruits which ripen later in the season may be sprayed with one and one-half pounds of

powdered arsenate of lead, two pounds of flour and three pounds of stone lime to 50 gallons of water. In most cases this can be applied on late ripening fruit up to June 25th.

Elms may be protected from this insect as well as from the elm leaf beetle and in most cases it is probable that one spraying will care for both insects. A Japanese beetle infestation, however, so far as shade trees are concerned, would necessitate spraying some others in addition to elm, especially linden, horsechestnut and willow. The recently developed coated arsenate of lead has proved excellent for shade trees.

Experience in New Jersey suggests that three seasons may elapse between the sparse infestation and a great abundance of the pest. Since swarms of these insects are most favorable to the future spread, it is by all means advisable to begin spraying early in the history of an infestation and thus not only check spread but prevent probably serious local injury.

The injury to lawns by grubs must not be overlooked. A practical method of destroying the pests on golf greens has been worked out by federal agents. It consists of treating the soil with a diluted solution of carbon disulfide emulsion. This is prepared "by mixing one part by volume of cold-water-soluble resin-fish oil soap, three parts of water, and ten parts of carbon disulfide. The soap and water should be agitated in a churn (an ice cream freezer is also very satisfactory for this purpose) until an even mixture is obtained; to this the carbon disulfide is added and the whole churned until it emulsifies, as indicated by a change in color and a creamlike consistency of the liquid. One quart of the emulsion thus obtained is stirred into 50 gallons of water, and the resulting mixture is applied at the rate of three pints to each square foot of turf. To treat a golf green properly the turf should be maintained in a moist condition for at least ten days prior to the application of the insecticide. The green should then be laid off into areas of about 1200 square feet and the proper quantity of solution applied to each area." An attachment has been devised for regulating the quantity of insecticide entering the water stream, thus permitting a direct connection with a water main and eliminating the necessity of a tank. A method is being worked out for treating soil with a poison and thus rendering it grub-proof for several years. This is especially desirable for lawns and golf courses.

Quarantine regulations require treatment for the destruction of the grubs for all classes of nursery stock which are commonly shipped with soil about the roots. Carbon disulfide emulsion is being used

extensively for this purpose for such plants as arbor vitae, spruce, hemlock, rhodora, azalea, blueberry, hydrangea, ferns and similar plants besides various potted stock. This carbon disulfide emulsion is prepared as follows: A stock soap solution is made by adding 12.5 grams of resin-fish oil soap to 87.5 cubic centimeters of water, heating until dissolved and allowing the solution to cool. Add 20 cubic centimeters of this stock solution to 50 cubic centimeters of carbon disulfide and emulsify by agitation. Larger quantities may be emulsified by using a butter churn or ice cream freezer. The completed emulsion is white and has the consistency of thick cream.

A soap wormseed emulsion containing 0.5 cubic centimeters of ascaridole, the active ingredient of the oil of wormseed to three liters of water kills the grubs providing the temperature of the dip is maintained between 65° and 70° F. Japanese iris and sedum should be immersed for 15 hours and perennial phlox from nine to 18 hours, depending upon the quantity of soil present on the roots. The amount of soap needed varies and it is necessary to test each lot before emulsifying a quantity of wormseed oil.

BIBLIOGRAPHY

The following are a few of the important recent publications on this insect.

Hadley, C. H.

1922 The Japanese Beetle. Circ. no. 46. N. J. Dep't of Agric., p. 1-20

1924 The Japanese Beetle in Pennsylvania. Bul. 390. Pennsylvania Dep't of Agric., p. 1-19

Leach, B. R. & Johnson, J. P.

1925 Emulsions of Wormseed Oil and of Carbon Disulfide for Destroying Larvae of the Japanese Beetle in the Roots of Perennial Plants. U. S. Dep't of Agric., Dep't Bul. 1332, p. 1-17

Smith, L. B. & Hadley, C. H.

1926 The Japanese Beetle. U. S. Dep't of Agric., Dep't Circ. no. 363, p. 1-66

ASIATIC BEETLE

Anomala orientalis Waterhouse

Great interest was aroused in this recently introduced beetle when specimens were found at Jericho, Long Island, in July and later discovered to be somewhat abundant in New Rochelle, Mount Vernon and White Plains, Westchester county, especially as this insect had been discovered in 1920 in New Haven, Connecticut, and up to the past summer was supposed to occur nowhere else on American soil.

This insect is a native of Japan and was very probably introduced in shipments of nursery stock having soil about the roots. It attracted notice in Connecticut first in the fall of 1922 when the grubs killed grass in a patch some eight by ten feet in a front lawn. The following spring other residents of the neighborhood were troubled by similar conditions. The infestation in Connecticut appeared to be a very restricted one and limited to a few city blocks.

History in New York State

There have been for some years complaints of injury to lawns in New Rochelle and Mount Vernon and invariably the reports were made so late in the season that little could be done in identifying the insect responsible for the damage. It was assumed in some cases that the trouble was due to the work of one of our native species of May or June beetle.

The extensive lawn of the E. H. Gary estate at Jericho was seriously damaged by some insect in 1925, and owing to the possibilities of Japanese beetle infestation in that section, H. L. King of the United States Japanese Beetle Laboratory made an examination in July 1926 and succeeded in finding Asiatic beetles rather common about the roots of the grass and just a little below the surface. Collecting in company with C. H. Zimmer on July 22d, the writer found thousands of the beetles upon the older blossoms in the rose gardens. They were mostly upon the somewhat faded white roses, only a few being found upon the others. The beetles feed to a slight extent, the work of five of these pests equaling that of one rose beetle. The *Anomalas* sometimes work well down among the petals but more usually they were clustered at the base of the recurved petals and sepals, in some instances nine being found upon an individual blossom. Observations in this garden showed that the beetles fly somewhat readily and when disturbed would easily clear a hedge several feet in height. Examination at that time and by federal scouts later showed that the infested area extended for more than a mile from this apparent center.

The conditions at Jericho and also those at New Rochelle and Mount Vernon particularly suggest a somewhat different behavior than evidenced by the very restricted distribution of this insect observed at New Haven.

There has been some damage by this insect to lawns at White Plains and one individual stated that he had known of this type of injury for ten years. This statement is put on record, not that it is considered conclusive evidence but simply that it gives about

the only data available as to the length of time this insect may have been established in New York State. It is possible that all of the known American infestations by this insect originated from shipments of one season.

Economic Importance

This species appears to be of economic importance largely on account of the damage it causes in lawns. The grubs feed upon the roots of the fine grasses and sometimes become exceedingly abundant. Friend records as many as 1000 grubs to a square yard. Affected lawns show bare spots here and there with a growth of various coarse weeds. The damage from spring feeding by the grubs is not so evident as that occurring later in the season. Since adults appear to fly relatively little, infestation is quite local, at least in the cases coming under observation.

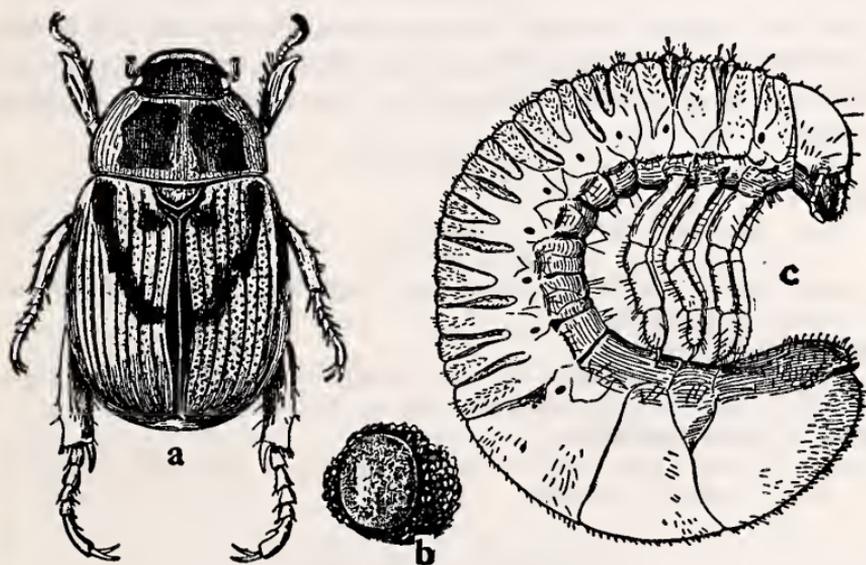


Fig. 33 The Asiatic beetle, *Anomala orientalis*; a, adult beetle; b, egg; c, grub or larva; all enlarged about five times. (After Britton)

Description

The beetle is moderately slender with a length of one-fourth to three-eighths of an inch and is yellowish brown with various blackish markings ranging to almost black. The color varies to such an extent that some specimens resemble the native light-loving *Anomala* (*Anomala lucicola* Fabr.) very closely (see fig. 33). The common native species may be distinguished readily from the recently introduced Asiatic beetle by the distinct projection of the

metasternum as a rounded, somewhat protuberant process between the middle coxae, whereas there is no such process in this new pest.

The grubs present an appearance very similar to that of the much larger white grub, and when full grown are about an inch long. The accompanying illustration gives an excellent idea of the beetle, its egg and the grub.

Life History

There appears to be one generation annually, although Friend has observed indications of a biennial habit in a portion of the insects. The beetles appear in midsummer, feed to some extent and deposit their eggs at or near the roots of various grasses. The grubs may be found in the soil in the early fall and on the approach of cooler weather descend some ten inches for the winter.

Control

The very limited feeding of the beetles restricts control largely to destruction of the grubs with a carbon-disulfide emulsion or calcium cyanide as recommended elsewhere for the grubs of the Japanese beetle.

BIBLIOGRAPHY

Britton, W. E.

1923 An Asiatic Beetle in Connecticut. Conn. Agric. Expt. Sta. 22d Report State Ent. for 1922, p. 345-46

1923 The Asiatic Beetle. Conn. Agric. Expt. Sta. 23d Report State Ent. for 1923, p. 291-93

Zappe, M. P. & Garman, P.

1924 Tests of Insecticides for the Control of the Asiatic Beetle. Conn. Agric. Expt. Sta. 24th Report State Ent. for 1924, p. 294-99

Britton, W. E. & Zappe, M. P.

1925 Further Notes on the Asiatic Beetle. Conn. Agric. Expt. Sta. 25th Report State Ent. for 1925, p. 309-12

JAPANESE SERICA

Aserica castanea Arrow

A newly introduced insect has attracted considerable notice in New York State, although it was reported earlier and at first supposed to be a native species.

August 1923, Thomas Bicket, 256 Sickles av., New Rochelle, submitted for identification specimens of a small brownish beetle, stating that they were eating his dahlia plants, that they issued from the ground at night and flew to the foliage and when viewed with a flashlight resembled red berries on the plants. The insects were also troublesome on neighboring property. Later he stated that

these beetles also destroyed asters, calendula, young chrysanthemum plants and in a neighboring garden an entire patch of lettuce.

The insects were sent to Washington and identified as *Serica parallela* Casey. The correspondence was with Dr M. D. Leonard, then associate state entomologist and a brief account of the infestation is given in New York State Museum Bulletin 253, page 35, 1923.

This insect attracted notice next in July 1926, as a result of a Japanese beetle circular falling into the hands of Mrs Louise V. Ryan, 641 East Lincoln av., Mount Vernon, who sent specimens to the Japanese Beetle Laboratory at Riverton, N. J., accompanied by the statement that her grounds were being overrun with thousands of the beetles. Suspecting a possible Japanese beetle infestation, R. J. Sim was sent to Mount Vernon, and his report together with a copy of the letter from Mrs Ryan was kindly placed at our disposal by Dr L. B. Smith, in charge of the Japanese beetle work. Similarity in the description of the infestation by Mr Sim suggested at once the earlier account, and since there was fortunately a good series of the beetles sent in by Mr Bicket in 1923, it was comparatively easy to establish the identity of the insects taken then with those found in 1926. The final identification was made by Doctor Arrow of the British Museum.

Description

The beetle is a dull reddish brown insect about three-eighths of an inch long, one-quarter of an inch wide and suggesting in a general way a very small May beetle or June beetle except that the wing covers bear a series of rather strongly marked minutely punctured longitudinal grooves. The various species of *Serica* or *Aserica* resemble each other so closely that no one but an expert can identify them with certainty.

The grubs closely resemble those of the much larger and better known white grubs of June beetles and like them feed upon the roots of various plants, especially grasses.

Habits

The beetles occur during the daytime in the earth about the base of various garden plants, usually within an inch of the surface. In some localities they must be extremely numerous since Mr Sim estimated that there were nearly 500 in approximately one square yard of earth about the base of a clump of perennial phlox. The adults appear above ground in early evening and by 10 o'clock may be fairly swarming on nearly all garden plants both vegetable and

flower, on the lawns and to some extent in fruit trees. The beetles, as stated above, somewhat resemble red berries as they are seen upon the foliage. Mr Sim records the beetles with notes as to the extent of feeding upon the following plants: asters (much), sun flower, chrysanthemum, salvia, sweet william, rose, holly hock, phlox, English primrose, morning glory, marigold, gaillardia, carrots, raddish, swiss chard, red beets (slightly), beans (slightly), spearmint, peach, plum, apple and raspberry trees, common ragwood (Ambrosia).

The grubs have been rather definitely associated with moderate or severe injury to the lawns, a number in the infested section showing areas of one to several feet of yellowing or dead grass.

Distribution

This insect is generally distributed in both New Rochelle and Mount Vernon, in the latter being found fully 15 blocks from the original infestation. G. M. Coddling of the Bartlett Expert Company records observing about midnight August 5th 50 to 100 beetles at the Columbus Avenue Station in Mount Vernon and an average of ten or twelve on the sidewalk under each lamp post. It has been reported from Yonkers by Dr Albert Hartzell. There is also a report of the species being found in two northern New Jersey localities.

Economic Status

The beetles are somewhat voracious feeders and when abundant may cause considerable injury especially to plants in small beds. Mr Bicket was of the opinion that poison gave no protection. Very likely the insects were so numerous that new arrivals concealed the actual killing. It is quite probable that calcium cyanide could be used advantageously to kill the beetles when sheltered in the soil during the daytime. This can be used to the best advantage only when the soil is somewhat dry, and better results would be secured if the insecticide was covered lightly. The amount can be determined only by trials, care being taken not to apply it too near to the stems of the plants.

BIBLIOGRAPHY

Arrow, G. J.

1913 Coleoptera of Japan. Ann. Mag. Nat. Hist., 12:398 (Autoserica)

Hartzell, Albert

1926 *Aserica castanea* Arrow. Econom. Ent., Jour. 19:868

Leonard, M. D.

1923 (*Serica parallela* Casey.) Nineteenth Report of the New York State Museum, p. 35 (as *Serica parallela* Casey)



Fig. 24 Grape leaf destroyed by feeding of the Japanese beetle. The soft tissues have all been eaten and only the network or veins remain



Fig. 26 Japanese beetles feeding on a peach



Fig. 25 Linden defoliated by the Japanese beetle



Fig. 27 Japanese beetles feeding on peach fruit and foliage. (After Smith & Hadley, U. S. Dep't Agric. Circ. 363)



Fig. 28 Apples damaged by the beetles. These were apparently sound before being attacked by this insect. (After Hadley, N. J. Dep't Agric. Circ. 46)

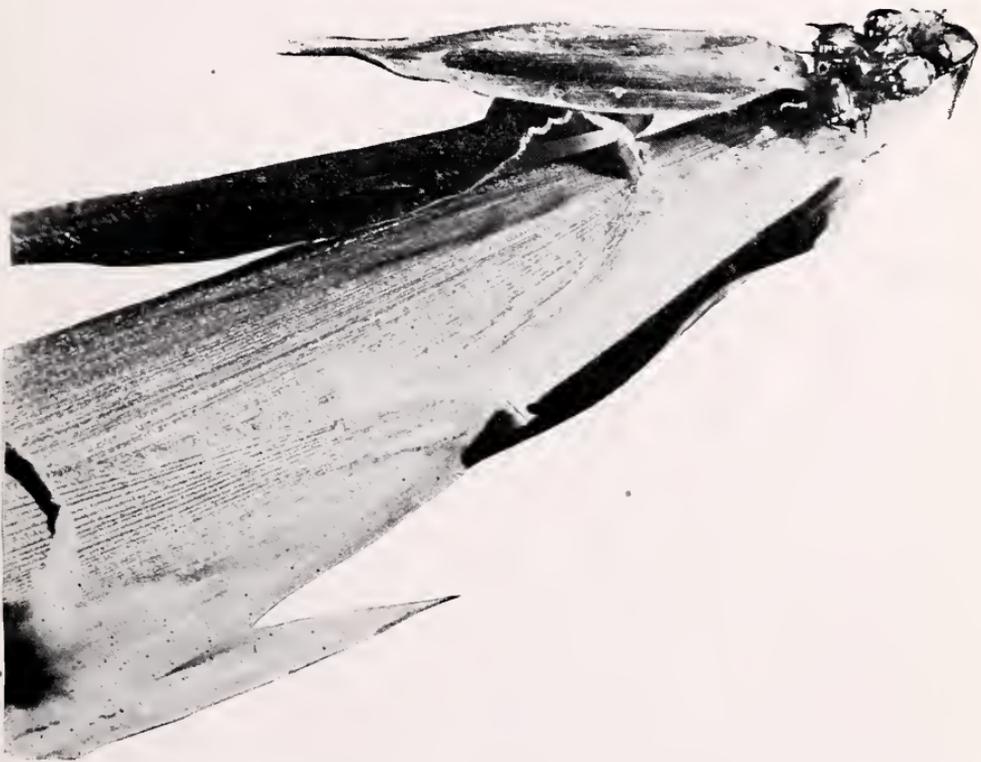


Fig. 29 Tip of ear showing how Japanese beetles may conceal themselves beneath the sheaths of green corn and thus be carried to uninfested places



Fig. 31 The grub or larva of the Japanese beetle enlarged. It is similar to though smaller than our common white grub. (After Hadley, N. J. Dep't Agric. Circ. 46)



Fig. 32 Dead sod turned back to show abundance of grubs of the Japanese beetle and the depth to which they feed. (After Smith & Hadley, U. S. Dep't Agric. Circ. 363)

OBSERVATIONS AND NOTES ON INJURIOUS AND OTHER INSECTS OF NEW YORK STATE

By

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Museum*

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APPLE AND THORN SKELETONIZER

Hemerophila pariana Clerck

The apple and thorn skeletonizer has greatly extended its range during recent years. In 1922 and 1923 it was very abundant and destructive on unsprayed apple trees in northern Columbia and southern Rensselaer counties. There was a relatively great extension the latter year from southern Rensselaer and Albany counties northward to Whitehall and the vicinity of Glens Falls, to the west slope of the Catskills in Greene county and to Cobleskill in Schoharie county, as determined by Dr M. D. Leonard, then associate state entomologist.

The insect was observed somewhat generally at Oneonta in October 1926, reported by Dr Hugh Glasgow as generally prevalent about Geneva, and through the kindness of Professor P. J. Chapman it is learned that the skeletonizer was sent in from Auburn, Clyde, Macedon, Skaneateles and Cohocton, these records indicating a somewhat general distribution in central and southern New York.

The observations in 1923 to 1925 showed that this small moth was very generally distributed in the foothills of the Berkshires, even

isolated trees or groups of trees miles from orchards of any size showing moderate to severe infestations. This very general spread suggests that winds have been the principal agents in carrying the moths over extensive areas. The wide distribution of this insect in southern New England indicates spread in the same manner.

There was a comparatively small extension of the infested areas in 1924 in eastern New York, except that the insect was found in small numbers along the Mohawk valley westward to Little Falls. Observations that season in Albany and vicinity showed the occurrence of three generations, the larvae of the first becoming full grown about the middle of June, a few still being seen on the 20th, while on the 25th most of them had spun up. On August 10th most of the second brood had made their cocoons, and adults developing therefrom were observed on the 22d. Small larvae of the third brood were seen September 7th, there being an interval between these and the preceding generation when none were to be found. Small larvae of the last generation were also seen as late as September 24th and even early October, the latter at Whitehall. A few partly grown larvae were found near Cobleskill October 13th.

Investigations during midsummer of 1924 in northern Columbia county in company with A. B. Buchholz, county agent, showed an unfortunate condition in certain orchards in the Harlem valley. The trees had suffered severely early in the spring from the work of the apple tent caterpillar, *Malacosoma americana* Fabr., and the rather serious injury by the skeletonizer the preceding season as well as severe damage that season had greatly reduced the vitality of the trees. Three-quarters of the trees in one young orchard had very small pale leaves, and with a continuance of such insect depredations one might expect the death of large portions of the trees and the practical ruin of the orchard. Good-sized limbs on a few of the trees had already died. These conditions, it should be remembered, were to be found only among unsprayed trees.

Somewhat severe injury was observed in Greene county both north and south of Catskill in 1924, although the damage was not so great as recorded for certain Columbia county orchards. That the third brood that season was small was most fortunate for the badly infested trees. There was a marked decrease in the abundance of the skeletonizer in the older infested areas in 1925 and 1926.

The young caterpillars work very largely on the underside of the leaves, especially along the midrib, although occasionally they are found near the margin. Irregular holes about the size of a pin head are eaten through the lower epidermis, the caterpillars excavating

the delicate tissues to the upper surface of the leaf. The latter dries, turns brown and produces a distortion or bulging up of the leaf somewhat suggestive of old injury by redbug, except that the latter is the work of a sucking insect which does not devour the tissues. Very early infestations are easily recognized by the irregular, scattered, brownish spots on the upper surface of the leaves. These are sometimes rather thick and on the under surface there may be found evidence of feeding, and usually young caterpillars under a thin, somewhat dirty web. There are usually two to three, sometimes four or five, and occasionally six or seven of these caterpillars on a leaf. When they are about half grown or thereabouts they move to the upper surface of the leaf and work is confined almost entirely to the older leaves, even those which have been curled by rosy aphid being acceptable.

The Entomologist, in collaboration with Dr M. D. Leonard, then associate state entomologist, prepared a revision of Cornell University Extension Bulletin 86, The Apple and Thorn Skeletonizer and Its Control, which was issued in May 1924. The reader is referred thereto for a general account of this insect.

Experience has abundantly demonstrated the efficacy of spraying with arsenate of lead for the control of this insect. Even one application as for the codling moth will usually prevent serious injury.

LIME TREE WINTER MOTH OR TEN-LINED INCH WORM

Erannis tiliaria Harris

The history of this comparatively unknown species for the past few years is a striking case of fluctuations in insect life. The yellowish, black-lined, looping caterpillars with orange colored heads are present in small numbers from year to year and only occasionally attract notice.

During the spring of 1924 these caterpillars were somewhat abundant here and there in different sections of the State but in no case did they attract notice on account of extensive defoliations. The insect sprang into importance early the following October through the appearance of millions of moths around the lights of cities and villages of the Hudson and Mohawk valleys. They were so abundant at Schenectady one evening as to cover store fronts, doors etc., from one end of State street to the other. Thousands were seen in Albany resting on the Capitol and Education Building and they were also abundant in nearby villages. A drive one evening in the vicinity of Albany showed that the moths were somewhat prevalent in the country districts as well as about city and village

lights. In addition to the localities already mentioned, the moths attracted attention at Upper Red Hook, Catskill and Athens in the Hudson valley and at Sharon Springs, Ithaca and Geneva in the central and west central parts of the State respectively.

The extraordinary abundance of the moths in October 1924 suggested a great increase in the numbers of voracious loopers another spring, something abundantly justified by the numerous records which were brought to our notice in the early part of the season.

The Adirondacks were generally infested in 1925 with local stripping here and there as shown by the following records:

Essex county. The work of the loopers was very common at Elizabethtown and vicinity, the trees in the village showing some though not serious feeding, an occasional linden on the outskirts having its foliage badly eaten. The larvae were somewhat numerous June 17th in the woodlands upon Cobble hill and here and there a few trees or groups of trees were somewhat seriously eaten, and on the edge of the woodlands the foliage of apple trees had been badly damaged. Higher up the mountain there was some feeding upon maple and birch, although in no instance was there anything approaching general stripping. Soft maples here and there upon the highway from Westport to Elizabethtown and again from Elizabethtown to Keene Valley showed injury in restricted areas, and Howard Notman of Keene valley stated that there was considerable feeding upon some of the nearby mountains, the caterpillars being especially numerous upon sugar maple and birch. Saul Philips of the State Conservation Commission stated that the caterpillars were very abundant in the woodlands in the town of Moriah and observations later showed many trees here and there in a partly defoliated condition. Reports were also received from Conservation Commission foresters and rangers to the effect that the insect was abundant or very destructive in the following localities: Blue Ridge, Keeseville, Lake Placid, Minerva, Newcomb, Olmsteadville and Schroom Lake.

Warren county. Assistant Superintendent of State Forests W. G. Howard, stated, on June 12th that he had found the insects very numerous on the ridge west of Glens Falls, and A. S. Hopkins observed the caterpillars generally from Lake George village to Ticonderoga and from Lake George to Chestertown, adding that they seemed to be present in almost countless numbers. The feeding in Warren county, however, did not appear to be quite so general nor extensive as in Essex county. Rangers and fire wardens of the Conservation Commission reported this insect as very abundant from the following additional localities: Adirondack, Bolton,

Horicon, Johnsbury, North Creek, Prospect mountain and Stony Creek.

Hamilton county. Numbers of the State Conservation Commission forest fire protective force reported the caterpillars as abundant or very abundant in the following localities: Blue mountain, Indian lake, Long lake, Piseco, Speculator and Wells.

Franklin county. The caterpillars were reported as abundant from McKenzie mountain and Meacham lake by forest rangers or fire wardens.

Other counties. These caterpillars were locally abundant in Saratoga, Washington and Rensselaer counties, although since the foliage injury occurred mostly at the higher, more remote areas, it largely escaped observation. In the town of Poestenkill, for example, the loopers were particularly numerous on trees at elevations of 1000 feet or more and were hardly noticeable at lower levels, although some nearly stripped soft maples, probably the work of this insect, were observed along the Hudson river near Castleton, a little south of Albany, and somewhat general feeding of this type along the shores of Lake Champlain, both in New York and Vermont.

There was some injury by this insect in the Catskill mountain area, it apparently being more marked in Greene and Delaware counties, although there was some in Ulster county.

There was decidedly less injury by this insect in 1926.

Habits

The full-grown caterpillars desert the trees in June and transform to pupae in earthen cells from five to six inches below the surface, the moths issuing late in October or early in November. The female is wingless and has a yellowish body sprinkled with black dots, while the male has a wing spread of nearly two inches, the forewings being a rusty buff sprinkled with brown spots and with two wavy brown lines, the inner one often indistinct.

As in the case of other canker worms, the female deposits her eggs in small clusters upon or under the bark of various trees. Specimens of females and eggs were received December 15, 1925, accompanied by the statement that the insects were observed in some numbers under the loose bark of presumably forest trees near Salem, Washington county, this record suggesting probable abundance another season.

The young caterpillars hatch in early spring and eventually develop into loopers having a length of about $1\frac{1}{4}$ inches. They are easily recognized by the orange head and yellowish body, the

latter marked dorsally with a series of ten somewhat broken, wavy black lines. These pests are frequently associated with the more common canker worms, namely, the fall canker worm, *Alsophila pometaria* Harris and the spring canker worm, *Paleacrita vernata* Peck., and like them are general feeders. They have a marked preference for linden, though they are also frequently abundant upon elm, various forest trees and apple foliage. Soft maple and certain oaks appear to be favorites in some localities.

Since the females are wingless, the invasion of a city or village by millions of the moths does not mean increased damage to city and park trees. The real danger is from the egg-laying females which latter can crawl only a very short distance and must therefore remain near or upon the trees frequented by the preceding generation.

English sparrows were observed destroying many of the moths in different cities, and yet for reasons pointed out above this is of little practical advantage.

The most satisfactory method of controlling this canker worm and associated early leaf feeders is by timely spraying with arsenate of lead, using about three pounds of the powder to 100 gallons of water and making the application before there has been any great amount of feeding. Such measures, however, can be recommended only for the somewhat valuable shade and orchard trees.

NOTES ON VARIOUS INSECTS

Species Attacking Fruit Trees and Small Fruits

Pear midge, *Contarinia pyrivora* Riley. The work of this introduced pest is becoming increasingly abundant in the upper Hudson valley. Infested pears, about the size of a marble, are easily recognized by their globular shape in comparison with the normal fruit. Within these fruits one may find a number of whitish or yellowish orange maggots, or when they are nearly mature the infested fruits may crack on one side, especially during a rainy period, and the maggots drop to the ground. They enter the soil and remain over winter, the small black midges issuing in the spring about the time the blossom buds begin to break. The eggs are apparently laid in the opening buds, the young maggots working down at the base of the stamens and establishing themselves in the carpel cavities of the developing fruit. Clapp's favorite pears are very subject to attack, and seckels, under certain conditions at least, are nearly immune. The degree of injury may be correlated with the development of the flower buds at the time the midges appear above ground.

The wintering of this insect in the upper soil layers under the tree suggests that early spring cultivation may be of considerable service in destroying the delicate pupae or even the flies, particularly if the cultivation is just as the flower buds begin to start. There is also a possibility, when the soil is not too wet, of destroying many of the insects by the judicious application of calcium cyanide.

Small strawberry beetle, *Heterostomus pulicarius* Linn. This small European insect has caused no apprehension among strawberry growers during the past two seasons, although it aroused the fears of a number in May 1922. It was first brought to attention by John Kreig, Linlithgow, who found the beetles working at the very base of the blossoms and producing small blackened areas, due to their feeding upon the developing anthers and adjacent tissues. He was of the opinion that even such injury would result in malformed berries, and he also called attention to most serious damage by this insect from their feeding upon and producing a bad browning of nearly the entire surface of the developing fruit. Badly affected blossoms would obviously produce nothing. The injury is of a type which could be easily overlooked or attributed to other causes.

An examination that season resulted in finding the insects in strawberry beds in Burnt Hills, Saratoga county, although the damage was not so serious as in Columbia county. Characteristic signs of injury were detected in strawberry beds south of Albany. The insect is also known to occur in Schoharie and Columbia counties and has been recorded from near Boston, Mass., and Milford, Conn. (Britton, 1922, p. 311).

The probabilities are against this recently introduced insect becoming a serious pest, although it may cause somewhat severe local damage as a result of unusually favorable conditions. Strawberry beds should be watched rather carefully at blossoming time, and if injury of this type begins to appear, the insects can be checked by liberal dusting with arsenate of lead.

European corn borer, *Pyrausta nubilalis* Hübn. There have been ominous developments in the European corn borer situation in the past three years. There has been a great increase in the size of the infested area so that now practically three-fourths of the arable land of the State is infested and the insect may be found in every county north and west of Delaware, Greene and Columbia counties. There are also infestations on Staten Island and the western end of Long Island. The remainder of the corn-growing area of the State will doubtless become infested within a

few years. This spread was to be expected, although it occurred somewhat more rapidly than was anticipated.

The most significant development has been the somewhat consistent increase in the infestations in certain areas, at least from 1924 to 1926 inclusive. This has been particularly marked in the Lake Erie region, especially in the vicinity of Silver Creek, though it is true also of most of the towns bordering the lake and those adjacent thereto. The stalk infestations in some of the earlier fields have amounted to 90 per cent or even more, there has been a 50 per cent ear infestation and in some of the more badly injured fields it was not difficult to find 15 to 30 borers in an individual plant. Such infestations mean considerable commercial loss and growers of sweet corn with a 50 per cent ear infestation are very likely to have their produce discriminated against in the open market. There has been a smaller though not so general an increase in the infestation in the early corn of the Scotia area, most of the severe damage being limited, as in the western part of the State, to the river bottom land or fields in the near vicinity of such areas.

The loss in New York State from depredations of the European corn borer is not serious. The increased infestation noted above, taken in connection with the extremely destructive work of this pest in Essex and Kent counties, Ontario, a section in which a very large proportion of the fields of early planted corn has been practically destroyed, has justly aroused serious apprehensions. It may be said of the above-mentioned Canadian areas that the infestation in the past few years presumably has been intensified to a very considerable extent by the great reduction in the corn acreage, this amounting in certain sections to 90 per cent. There is no way of approximating the proportion of the injury due to the reduced acreage and the only safe plan is to adopt measures which will greatly reduce the numbers of this pest. An extensive educational campaign was organized in the fall of 1926 for the purpose of bringing about so far as possible a general clean-up of the more badly infested fields, special emphasis being placed upon cutting the corn low and early, and thoroughly plowing under the stubble.

A Revision of Cornell Extension Bulletin 31 has been prepared and gives somewhat detailed information respecting this insect, its habits and in particular directions for its control.

Species Troublesome to Man

Bat bedbug, *Cimex pilosellus* Horv. This insect resembles the bedbug of dwellings, *Cimex lectularius* Linn.,

so closely that its occurrence in houses creates as much dismay and consternation as the presence of our too well-known domestic parasite, although it confines its attentions to bats and only occasionally invades nearby sleeping apartments. The two resemble each other so closely that only an expert can distinguish between them.

The presence of this insect was brought to our attention in 1921, at which time the bat frequented attic of a brick building at Rensselaerville was overrun with these bat bugs. The summer of 1925 a similar infestation in a dwelling in Saratoga Springs was brought to notice. The walls of the house had been the nesting place for hundreds of bats and the parasites were occasionally invading the sleeping rooms. The situation was so serious that the owner had edges of the mansard roof raised so as to permit access to spaces between the timbers of the walls. Some of these spaces had been the homes of numerous bats and hundreds of them were killed. There was an excellent opportunity to test the efficiency of the recently developed calcium cyanide dust, and in cooperation with the Entomologist, Dr William Moore dusted these cavities with this preparation, putting about a teaspoonful in each space between the timbers, and in addition blowing a somewhat indeterminate quantity into these spaces.

The dust drifted down and appeared to penetrate the floor spaces thoroughly, some odor of acetylene gas being noted in the rooms of the third floor, the walls of which were inhabited by the bats. The tin roof was replaced immediately after the dusting and apparently everything living was destroyed both bats and bugs. The odor of acetylene gas and presumably a little hydrocyanic gas lingered in the upper rooms, and about 1:30 o'clock in the afternoon, at that time, some two hours after the treatment, the gas had disappeared so thoroughly that there seemed no probability of any ill effects were the rooms occupied. It should be stated that although the house was vacated during the fumigation and care taken that nobody was where there was even a slight possibility of inhaling hydrocyanic acid gas, the writer was in the building most of the time, frequently on the third floor where there would presumably be the greatest density of the gas in case any material amount entered the rooms through the somewhat porous plaster walls, and yet experienced no ill effects. This would have been unsafe if the windows and doors on both floors had not been open previous to the treatment and thus insured thorough ventilation. Since only a light breeze prevailed, there was no greater ventilation than can usually be secured.

The treatment was entirely satisfactory and it seems possible to use this material in dwellings for the destruction of various insects, although care should be exercised not to incur undue risks. The ready and moderately slow release of hydrocyanic acid gas makes the process much simpler and less dangerous than the older method of using this insecticide.

A flesh fly attacking man. (*Wohlfartia vigil* Walker). A very unusual case came to notice the past summer. It was a request for the identification of a first-stage larva (see fig. 34) less than $1/25$ of an inch long, which was removed with several others from the conjunctivae of a man affected with some conjunctivitis and resident in Cattaraugus county, New York State. The insect was provisionally identified as the very young larva of the above-named insect.

The history of the case is as follows: A stone worker in good health thought he felt a piece of marble fly into his eye and as a result of continued pain he consulted a doctor that evening, the latter finding nothing. The next day an oculist was consulted. A very small cyst was observed. It was removed and found to contain several living maggots. A photomicrograph of one is shown in figure 34. It will be noted that this maggot is provided with a pair of heavy, hooked jaws, evidently very efficient instruments for making its way into tender tissues. The body is also armed with series of short spiny processes. The presence of several such creatures in the eye would undoubtedly cause severe pain. This insect is normally a flesh fly, only very occasionally attacking human beings.

This is by no means the only record of the kind for the country, although it appears to be the first for the United States. Dr E. M. Walker (1920) placed on record two cases of young children being afflicted with boil-like, red pustular sores half an inch or so in diameter. Each sore had a minute and very inconspicuous opening, and from each one or more maggots were obtained. These sores were restricted to the exposed upper parts of the body, the neck, shoulder and arms. Two years later the same author reported another case likewise in the vicinity of Toronto, the patient, as in the preceding instances, being a child.

The related European *Wohlfartia magnifica* Shiner has been rather commonly associated with maggot infestation of the eye, nose and ear, the loss of sight, hearing, and in very extreme cases, death has resulted. This fly is somewhat prevalent in southern Russia.

The American records indicate a certain amount of danger from this fly, though as a rule it can hardly be great. The development

of such sores or the continuance of pain in a tender organ such as the eye should serve as a warning and be speedily followed by competent medical examination. Otherwise serious results may follow.

The following references relate to *Wohlfartia vigil*:

Anon.

1924 Fly Larvae as Human Parasites. Health News. N. Y. State Department of Health, September 1924, p. 156

Felt, E. P.

1924 *Wohlfartia vigil* Walker attacking Man. Econ. Ent. Jour. 17:603

Walker, E. M.

1920 *Wohlfartia vigil* Walker as a Human Parasite. Jour. Parasitology, 7:1-7

1922 Some Cases of Cutaneous Myiasis, with notes on the larvae of *Wohlfartia vigil* Walker. Jour. Parasitology, 9:1-5

Blue bottle fly maggot in child. Dipterous larvae were submitted for identification to Dr M. D. Leonard, then associate state entomologist, in October 1923 by Doctors Ruth Gilbert and E. J. Early, both of the State Department of Health. The specimen represented a rather unusual condition of myiasis in a child, some 20 months old, of Guilford. The patient had been sick for 45 days and for the first three weeks the temperature had run from 103° to 106°, though there was a continued application of an ice pack to the head. During the second week the child developed true meningeal symptoms, these continuing for about five days. There was no pain, although there was some abdominal distention which was easily relieved by enema or tube. At no time was there any definite train of symptoms permitting a diagnosis. In November it was stated that the child had a temperature of 102 and was taking a normal amount of nourishment, but was very sick. After the use of calomel, one dipterous larva, identified as above, was passed in the feces. Whether there was more than one maggot in the intestinal tract was not known. It is possible the infestation developed through the child gaining access to blown meat.

Doctor Keilin in his study of intestinal myiasis (1924, p. 318-20) states that the European *Sarcophaga-haemorrhoidalis* Fall. appears to be able to develop to full size within the intestines, although such is not the case with larvae of *S. carnaria* Linn. The larvae do not seem to live as parasites, but probably feed upon the partly digested and decomposed food they find in the intestines. The peculiar ability of *S. haemorrhoidalis* larvae to live under such conditions is probably due to the fact that the highly specialized respiratory system permits an aerobic mode of life.

Spring-tails in buildings. A number of specimens of *Entomobrya* sp. were received August 30, 1922, from Mrs B. Cahn of the Bronx, New York City, accompanied by the statement that they were unpleasantly numerous in a new 62-family apartment house. She stated that they were mostly on the window sills, although a few were found on the bed linen and furniture covers. The building is opposite a park. The specimens were kindly referred to the genus *Entomobrya* by Messrs Ewing and Folsom. Doctor Folsom states that this spring-tail is rather common in the eastern United States, being taken usually on the ground, under damp leaves or other objects. He adds that it may have occurred in the hair used for mixing mortar, since he has found collembolans among hog bristles near a slaughterhouse, and there are a few records of their occurrence among the feathers of birds and the hairs of living mammals (1901, p. 160-61).

Specimens of another spring-tail, kindly determined by Dr J. W. Folsom, Homer, Ill., an authority upon the group, as *Isotoma viridis* Vourlet, were received in November 1924 from one of the public laboratories in the city of Albany, accompanied by the statement that they were abundant in the washbowls of a toilet room located in the basement just below a window. Evidently these insects came from the adjacent soil, since Doctor Folsom states that this species is a cosmopolitan inhabitant of the soil and its occurrence therefore was simply casual.

Spring-tails in a well. A number of specimens of *Folsomia fimetaria* Linn. kindly determined by Dr J. W. Folsom of Homer, Ill., were received by Dr M. D. Leonard, then associate state entomologist under date of October 10, 1923. The correspondent, Clyde J. Benedict, Lewis, Essex county, stated that the insects occurred in a well about 16 feet deep, 2½ feet across and with a hemlock plank curb. The insects caused some apprehension. Doctor Folsom states that this species belongs to the soil fauna and often occurs about the roots of plants without doing any damage so far as known. He has received it several times from wells and the late Dr A. D. MacGillivray records having found it once in milk delivered by a milkman.

This insect is not adapted in any way to an aquatic existence. It is readily destroyed in wells or similar places by liberal applications of hot water, the use of steam or the exhaust products from an automobile.

Thousand legged worm, *Julus* sp., in the human system. A specimen was received October 3, 1922, through the State Depart-

ment of Health accompanied by a statement from the health office of one of the small cities that the milliped had been passed together with a large number of others by a child three years old which had suffered from convulsions. The known preference of millipeds for moist, decaying organic matter makes it difficult to explain how any such infestation could have arisen. The one specimen submitted for name was about three-fourths of an inch long and it hardly seems as though it could have developed within the child from an egg. They may have been ingested with partly decayed fruit.

Shade Tree Insects

Elm leaf beetle, *Galerucella xanthomelaena* Schrank. The elm leaf beetle has been present in the Hudson valley for many years and is becoming established in widely scattered parts of this State. Generally speaking, the injury in the Hudson valley has been much less during recent years, though occasionally there is serious injury. This was particularly marked in 1924 on elms from Poughkeepsie south, the trees upon entire blocks and occasionally larger areas being entirely skeletonized in midsummer. The unusually cool weather of the spring and early summer resulted in an extremely late development, and full-grown larvae and pupae were consequently found during July and even early August. The result was that the midsummer development was somewhat unexpected and many trees were damaged, which under more normal conditions would probably have been protected by spraying.

There was severe local injury in the Hudson valley north of Poughkeepsie, though as a rule this was restricted to comparatively few trees, usually those near some especially good shelter such as an open shed or belfry.

The English sparrow feeds upon this pest to a limited extent. Edgar Bedell of Waterford states that the birds appear upon infested trees early in the morning and after 5 o'clock in the afternoons. They hop slowly down to the tips of the branches, peering in all directions, and do not seem to have learned that the grubs are only on the underside of the leaves. They desert the trees after five to ten minutes and are relatively inefficient since they are not persistent and seldom take more than five or ten larvae while in a tree. At other times they may be observed fluttering around the trunk like humming birds and picking off the larvae or pupae or else hopping under the tree or at its base and picking up leaves or other insects. The exposed pupae in the crevices of the elm bark appear to be unmolested for the great part.

It should be unnecessary to add that the experience of the past 25 years has abundantly demonstrated the practicability of controlling the elm leaf beetle by spraying with a poison such as arsenate of lead. In other words, it is entirely possible for communities to protect the shade trees at a reasonable cost, and usually it is feasible to detect the work of this insect and estimate its probable abundance in ample time to spray and thus prevent serious injury, provided a spraying equipment and competent men are available.

Oblong leaf weevil, *Phyllobius oblongus* Linn. This European weevil was first discovered in this country in 1923 at which time R. E. Horsey of the park department, Rochester, sent specimens to Dr M. D. Leonard, then associate state entomologist, accompanied by the statement that the insects were common on elm from June 2d to 9th, two being found July 6th. It did not appear to do much damage and no attempt was made to control the insect by spraying. It was found only on three American elms 50 feet high or more. The infestation was just across the road from a large collection of crabapples from northeastern Asia and North America. There was no trace of the insect in the latter. Specimens were identified by Dr E. A. Schwarz through the courtesy of Dr L. O. Howard of the Federal Bureau of Entomology. There was nothing seen of the insect in 1924.

The discovery of this European species in America is a matter of some importance since a number of our injurious species have become established in just this casual way. It is difficult at the outset to forecast the developments of the future, and usually such infestations are allowed to remain unmolested until the insects have become so abundant and widely distributed as to make control and in particular exterminative measures exceedingly difficult if not impossible. The area where this insect was found should be watched closely during the next few years and measures taken if necessary to prevent the weevil from becoming a menace to our horticultural interests.

This insect is briefly noticed by Theobald (1909, p. 119-20). The weevil varies one-sixth to nearly one-fifth of an inch in length, is black, the elytra covered with dull brown scales, with a reddish tinge of pale gray, the borders dark almost black, the head and thorax covered with gray pubescence and also the wing covers. The legs are brown or yellowish. The weevils, according to Theobald, first nibble the young opening buds and later attack the leaves, occurring in England from the beginning of May until the end of June. Miss Ormerod states that grafted plants in nurseries are especially liable to attack, a type of injury also observed by Theo-

bald. The insects are very active in bright warm weather, sluggish on dull days and frequently occur in very large numbers in Kent and Sussex counties, though they may be found in other parts of Britain. Some years they cause material injury and in others when apparently abundant there is no damage. The females lay their eggs in the ground. The grubs feed on the roots of various kinds of plants. They are white, footless, slightly hairy and with a brown, horny head.

It is possible to collect the beetles in dull days by jarring them from the smaller trees. Arsenate of lead is presumably a fairly safe poison. Young grafted stock may be protected by the use of bands of grease and jarring the trees, many of the beetles being caught as they attempt to crawl back. Bands of tree tanglefoot would presumably be equally effective.

European hornet, *Vespa crabro* Linn. This somewhat recent European introduction is firmly established in the vicinity of New York City, ranging north in the Hudson valley to southern Rensselaer county. It usually attracts notice by injuring smaller twigs of trees and shrubs, the bark being gnawed off in irregular areas, sometimes girdling the twigs, the material being used in the construction of the large nests located frequently in cavities in trees, in confined places in buildings, as between the rafters, and less frequently underground. Twigs of lilac and apple, injured by this species, were received in October 1923 by Dr M. D. Leonard, then associate state entomologist.

An unusual and apparently new type of injury (see fig. 35) was brought to light in April 1926, rhododendron stems some two inches in diameter and collected at Cornwall presenting the general appearance of numerous light saw cuts. The transverse girdled strips were some $3/32$ of an inch in width and one-half to two and one-half inches in length. The bark and sapwood had been removed, the girdled areas being one-eighth to one-fourth or one-half an inch apart and extending or overlapping to such an extent as practically to girdle the largest portion of the branch.

The limb, in addition, bore evidences of earlier transverse injury, indicated by the approximate margins of callous tissue both below and above the insect injured portion. There is also older work on this branch, indicated in one section by a bare spot some two and one-half inches long and extending more than half-way around a portion of stem an inch and a half in diameter. This bare spot, judging from the slightly scored sapwood, was injured some two or three years earlier. The oldest scarring is margined here and there

by rather thick rolls of callous tissue, in a few instances this bordering a narrow transverse scar, though in most cases it is along the edges of a somewhat extended surface of exposed dead wood. The hornets have evidently been working on this particular stem for three and possibly four or five years. Injury to this valuable shrub is decidedly more serious than damage to the more common, quicker growing ornamentals.

Liberal spraying of the smaller branches in late May or early June with arsenate of lead is one of the most promising methods of preventing injury by these wasps. It is also possible to locate the nests and to destroy the inmates by the use of calcium cyanide. This latter would be the more effective if the nests in the vicinity are located.

Corythuca marmorata Uhler. Rather badly infested leaves of the Groundsel tree, *Baccharis halimifolium*, were received from R. E. Horsey of the department of parks, Rochester, under date of July 11, 1922, accompanied by the statement that the insects, kindly identified by Professor C. J. Drake, state entomologist of Iowa, seem to feed on either side of the leaf, although they were not very numerous at that time. He also adds that this is the first time they were noticed. They were found by John Bell.

An examination of the infested foliage showed a number of full-grown adults and in a few places on the leaves, especially near the midrib on both upper and under surface, were groups of small, blackened, oval spots, each showing near one extremity the truncate tip of an egg with its black center and light gray, rather whitish margin. There were also some irregular, blackish, varnishlike spots upon the margins of the leaves, presumably excrement.

Elm lace-bug, *Corythucha ulmi* Osborn and Drake. A small group of elms at Brainard, town of Nassau, has for the past four or five years shown a peculiar browning of the foliage in late summer and early fall. It was at first attributed to drought, later assumed to be the work of red spider since it continued year after year, the affected area extending somewhat each season, the last suggesting a somewhat local habit. Finally an examination September 28, 1925, showed that the injury at that time and with little question that of previous years was due to the work of a lace-bug.

An examination of the foliage on the latter date showed that the leaves were rather uniformly and badly browned, exuviae giving unmistakable evidence as to the identity of the insect and the spotting with black excreta further disfiguring the already badly affected leaves. Adults were collected at the base of the tree in

early October and kindly identified by Professor C. J. Drake as the above-named species. This is a comparatively new pest, being known in addition only from Lisbon, Ohio and Litchfield, Conn.

The insects hibernate as adults and since those found in early October were closely restricted to the near vicinity of infested trees and were sheltering in the surface débris, particularly old leaves, it would be comparatively easy to reduce the infestation greatly by burning over the ground or using calcium cyanide, much depending upon the size of the trees, their value and the surrounding conditions.

Japanese mealy bug, *Pseudococcus comstocki* Kuw. Bark infested by this insect, kindly identified by Dr L. O. Howard, was received in September 1922 from John F. Fairchild, accompanied by the statement that a number of catalpa trees in North Pelham, Westchester county, were infested. A considerable mass of whitish, cottony matter containing females and literally alive with the minute, pale yellowish orange larvae was submitted for identification. Evidently the insect was extremely abundant or it would not have attracted notice. Reference to earlier records showed that this species was exceedingly numerous on osage orange in New York City in 1927, producing masses several inches long of white, indistinct, waxy fibers and débris.

Forest Insects

European pine sawfly, *Diprion simile* Hartig. This relatively recent introduction is extending its range, becoming locally destructive as shown by the following records: August 25, 1923, Dr M. D. Leonard, then associate state entomologist, received larvae of this insect from Mrs O. J. Spahn accompanied by the statement that a small tree about four feet high at Pleasantville, Westchester county, contained hundreds of the larvae, many of the needles being destroyed. In a later letter she leads one to infer that there was considerable local injury, possibly by this insect, though some was presumably due to the work of the white pine weevil, *Pissodes strobi* Peck.

The same year Professor C. R. Crosby reported that this insect was eating the needles of long-leaf pine trees some six years old at White Plains, Westchester county, there being 150 to 200 on one tree.

A few larvae of this insect were found on white pine September 6th of the same year at Highland Park, Rochester, by R. E. Horsey and transmitted for identification to Doctor Leonard. This latter marks a considerable extension of range by this introduced species.

To date this insect has attracted little attention in New York State, though there are a number of records of its injuring trees in Connecticut.

Birch leaf skeletonizer, *Bucculatrix canadensisella* Chamb. There have been several extensive outbreaks by this insect during the past 25 years, one or two being especially widespread. There was a rather general abundance of the skeletonizer in the season of 1922, considerable areas being defoliated in the eastern part of the State particularly in the northern Hudson valley and in portions of the Adirondacks. The work of this species was most evident that season in the eastern portion of the State extending from the Adirondacks south into Albany and Schenectady counties. It was then reported as occurring on white birches generally from Lake George north to Lake Champlain, in many cases being so extremely abundant as to skeletonize the foliage completely. There was also injury reported that season from southern Westchester county and on Long Island. It was found feeding on a variety of birches in the Rochester public parks.

The season of 1923 was marked by comparatively little injury. Dr M. D. Leonard, then associate state entomologist, received specimens of the insect's work from Oneonta, Otsego county, and also from Luzerne, Warren county. Apparently it was much less abundant than the preceding year.

A very curious condition prevailed in late summer of 1924 in that the skeletonizer occurred in small numbers on birches through Saratoga and Schenectady counties in particular, causing hardly appreciable injury and practically none in the extreme eastern part of the State and in portions of Massachusetts within 20 to 40 miles of the New York State line. A little farther east, particularly on the northern and eastern slopes, the skeletonizer was extremely abundant, destroying all the birch foliage over large areas. Similar skeletonizing, we are informed through the courtesy of Professor H. T. Fernald of Amherst, was very apparent in eastern Massachusetts.

European birch sawfly miner, *Fenusa pumila* Klug. The work of this recently established European species first came to the writer's attention in the summer of 1923, its work being observed then in eastern New York and southern Connecticut. The species was first reared and its identity established by Messrs Britton and Friend (1924, p. 601) the authority responsible for the determination being Mr Rohwer of the United States National Museum.

The work of this insect at a distance is very suggestive of that of the birch leaf skeletonizer, *Bucculatrix canadensisella*

Chamb., although it is at once distinguished by the fact that this is a true leaf miner, the pale sawfly larvae working between the upper and lower epidermis of the leaf. This miner also limits itself very largely to the more tender terminal leaves, and when abundant may produce a characteristic browning of the foliage easily recognized at a distance. This insect apparently breeds throughout much of the season, possibly producing several generations, since its work has been observed in New York State from some time in June until well into September. This miner produces a broad, irregular blotch mine which quickly browns.

This small insect evidently drifts rapidly with the wind, since it appears to have become extensively distributed in western New England and eastern New York State within a short time. It was observed by the writer at South Hadley, Mass., in the Connecticut valley, in small numbers in the Berkshire region, and rather commonly from south of Albany north to Saratoga and westward to Binghamton. It was extremely numerous on the sandy birch-covered areas about Saratoga, in the vicinity of Albany and in southern Rensselaer county, acres of gray birches showing the characteristic browning of the younger, more tender foliage, this being especially marked in the case of birch sprouts three to five feet high. Fortunately the gray birch is a tree of little commercial value and the recent establishment of this insect is of relatively small economic importance.

A rare attack on pine. *Tetralopha robustella* Zeller, a species recorded in Dyar's catalog from Texas and Colorado, also reported from Florida and later from Connecticut, is certainly rare in the East and one very seldom brought to notice. There is a record in the report for 1918 by Dr W. E. Britton, state entomologist of Connecticut, pages 349-50, of an attack the preceding fall on white pine at Greenwich, Conn. The larvae lived in silken tubes extending through a globular mass of their droppings, the whole being two inches or more in diameter. Specimens of this insect were received by Dr M. D. Leonard, then associate state entomologist, in October 1923 from C. H. Zimmer. They had been collected from Austrian pine at Lynbrook, L. I. The species was identified through the courtesy of Doctor Howard by Carl Heinrich of the National Museum.

The caterpillar of this insect has been described by Doctor Britton as follows:

Length about one inch, light brown or tan with four narrow, black or dark brown longitudinal stripes, the middle ones being broader than the lateral ones; hair lines in the transverse sutures

between segments and also irregularly arranged. Head light brown, marked with black or dark brown patches. Legs and prolegs light brown, unicolorous with ventral surface. Scattered hairs are borne on the head, and dorsally, ventrally and laterally on each segment.

The following is Doctor Britton's description of the adult:

The moth has a wing expanse of about an inch, of a general grayish brown color, slightly more than a third and less than half of forewings at base, dark brown; beyond this is a broad transverse band of pearl gray with dark discal dot near center; apical portion grayish brown, lighter than base and nearly uniform with color of rear wings. Under surface nearly uniform grayish brown, the rear margins of forewings being somewhat lighter.

A parasite, *Meteorus* n. sp., identified by C. F. W. Muesebeck through the courtesy of Doctor Howard, was reared from this material.

Thorough and timely spraying with arsenate of lead would doubtless check this insect in case of a severe infestation.

European pine-needle miner, *Ocnerosstoma piniariella* Zeller. This European species was apparently first taken in this country at Ithaca by Professor J. H. Comstock in 1882. It was next brought to notice through the reception at this office of western white pine needles under date of June 28, 1922, accompanied by the statement that the material was collected at Hilltont's farm near Abbotsford, British Columbia, and that the larvae appears to mine one needle of the whorl and then forsake its gallery and spin a slight cocoon between the needles, the adults issuing the latter part of July as evidenced by specimens forwarded by Dr J. S. Boyce. The general character of the work is suggestive of our native pine leaf miner, *Paralechia pinifoliella* Chamb., except that this insect pupates in a loose cocoon constructed on the outside of the needles. The British Columbia material was identified by Doctor August Busck of the United States National Museum (Felt, 1922, p. 432-33; 1924, p. 351). The insect apparently has continued in small numbers at Ithaca, since specimens were captured there July 13th by Dr W. T. M. Forbes (1924, p. 173).

White pine weevil, *Pissodes strobi* Peck. The greatly increased planting of white pine in connection with the reforestation program of the State, brought the work of this insect to the front, since in certain areas at least it is a most serious enemy of pine trees two to ten feet in height or thereabouts. Observations in the past years have shown that pine plantings in sections where the native pines are bushy and greatly branched, are very likely to be seriously affected by this insect.

An examination of some seven acres of recently planted pines in northern Columbia county disclosed an interesting condition. The pines varied in height from approximately three to 15 feet and a very considerable portion, possibly 75 per cent, showed injury by the weevil. The growth of many of these trees was decidedly bushy. A few were noted where the leaders had been killed at three different periods of the development of the trees, and in some cases, two shoots were competing for leadership. There was evidence to show that some of the leaders might be rather seriously infested by the weevil and yet not killed. This was indicated by the stunted growth and the very rough, irregular, swollen areas on the affected parts. Occasionally this damage was severe enough to result in a small area of exposed dead wood several years after the initial injury. A very low percentage of the trees had made a rapid normal growth and possessed the strong leaders lumbermen like to see.

There were in the vicinity a number of larger pines and on these severe injury was noted at 20, 25 and even 35 feet from the ground, though damage of this character was proportionately very much less than in the case of small trees. It would seem, from a general survey of this planting, one could not afford to allow recently planted areas to become seriously affected by the weevils. It is believed that protection for even two or three years at the time maximum injury is likely to occur, namely when the trees vary in height from two to ten feet or thereabouts, would result in greatly reducing the ravages of this pest.

A moderately thick planting with the expectancy of a loss not exceeding 10 per cent may be advisable, though in this particular case the loss would run considerably higher. The interplanting of Scotch with white pine is also worthy of consideration since the rapid early growth of the Scotch pine protects the white pine to a considerable extent. The Scotch pines can be later cut for box boards or other cheap lumber.

The systematic cutting and burning of infested shoots in the first half of July or, better still, the placing of such infested material in barrels covered with ordinary mosquito netting, would result in checking the multiplication of the weevil, and if the latter course was pursued, the parasites could escape and continue their beneficial work. There is a serious defect in this measure since much injury is caused before the pest is checked.

The systematic collecting and destruction of the weevils during the warm days of early spring and continuing at three to five day

intervals until practically no weevils are captured, has the merit of destroying the insects before there has been any material injury. Furthermore, it affords a certain amount of protection for more than one season. The problem in connection with this last is to bring the operation within reasonable cost limits, and that by no means seems impossible.

Pales weevil, *Hyllobius pales* Boh. This insect is a well-known feeder upon the stems of young pines and has been associated occasionally with serious injury to small trees. It appeared in a new rôle (Felt, 1926, p. 795), in a recent planting of Scotch pine some 15 years old at Ballston Spa. The injury was brought to our notice in June 1926 by Dr H. H. York of the State Conservation Commission, and in his opinion 100 per cent of the trees were infested. They ranged from one and one-half inches to five inches in diameter and were set some ten to 15 feet apart. An examination at that time showed at the base of the trees below the surface of the ground considerable masses of pitch-infiltrated soil, and in cells of this material or working in the cambium of the trees, there were whitish grubs of this species and also some of *Pissodes*, probably *P. approximatus* Hopk. The young pines were bordered on two sides by old hard pines, the probable source of the infestation. A dead tree with a trunk diameter of two and one-half inches examined June 25th showed an irregularly eaten area completely girdling the trunk a little below the surface and more or less covered with exuded masses of pitch. A pine evidently possessed of considerable vitality and with a trunk diameter of three inches was irregularly girdled a little below the surface for about three-quarters of its circumference. The infested roots and adjacent soil were more or less moist and with a distinct resinous odor. Another tree in a similar condition had the girdled area extending approximately half way around the circumference and limited almost entirely to parts below the surface (see fig. 36). A larger tree with a leader growth for the season of 18 inches and equally satisfactory growth the preceding year and therefore presumably in excellent health, showed irregular workings at the base of the roots, although there was no girdling even on one side. In one case the borings extended along a large root for a distance of approximately four inches from the base of the trunk. The grubs were found working on or close to the living tissues as well as in the resinous matter and earlier rearings from grubs the last of June produced specimens of *Pissodes*.

An examination of the infested planting July 30th resulted in finding a few large pupae at the base of badly infested pines, one of

these transforming to a pales weevil the next day. The size of these pupae indicated their identity with the larger larvae observed earlier. At this date several of the badly infested pines had been broken off or tipped over by a severe wind.

On September 8th, four adult pales weevils were taken in this plantation at the base of a six-inch Scotch pine, there being a larva, a partly transformed adult, two tenereal specimens and one well-hardened beetle. The leader of this pine had grown about 12 inches and the tree appeared just a little off-color with the needles somewhat under normal size. The base of the tree was practically girdled and surrounded with pitch-infiltrated soil. This insect was not found elsewhere and none was taken at the base of obviously ailing trees, the latter indicating a presumably close relation to injured living tissues. No *Pissodes* larvae or adults were taken though careful search was made both above ground and at the base of affected trees. There was at this date a considerable number of pines which had yellowed or were yellowing rapidly, an indication that the earlier estimate of the infestation was substantially correct.

The offender is with little question the pales weevil, although as stated above some *Pissodes* were reared in the earlier part of the season. Even then larger grubs, presumably those of *Hylobius* were noticeably more abundant than the smaller ones, probably *Pissodes*, although the two were not differentiated at that time.

Spruce leaf miner, *Olethreutes abietana* Fern. This comparatively unknown insect, the light greenish larvae of which mine and web together the leaves of various spruces, was exceedingly abundant in different sections of New York State in 1925, infested material having been received from Buffalo, Rochester, Wilmington, Essex county, and collected in the vicinity of New York City. It has also been reported from the vicinity of Syracuse.

The infested blue spruce received from Wilmington on July 20th, consisted only of two very small twigs. They showed a few green needles and a great many brown, mined ones loosely webbed together, the web being rather well filled with castings and also containing numerous cylindrical brown cocoons thickly covered with minute castings and about one-fourth of an inch long and one-eighth of an inch in diameter. There were over 30 of these on the two sprays. A flat branch some 9 by 12 inches in major dimensions produced by midsummer 220 of the small grayish moths. A few of the small rather active, greenish caterpillars, a little over one-fourth of an inch long, were feeding at the time the material was received.

The eggs are deposited in midsummer in linear, overlapping series along the needle, in one case there being seven, the length of the series being about one-sixth of an inch and of an individual egg approximately $1/30$ of an inch. The eggs are pale yellowish, transparent, the green of the needle dominating on the thin margins and presumably affecting the color to some extent, even in the thicker part of the egg. They are so flat that they project only slightly above the shallow groove in the side of the needle.

A number of parasites, *Ascogaster provancheri* Dalle Torre, were reared and are presumably important natural enemies.

A related species, *Epinothia nanana* Treitsche, was reared from infested twigs of Norway spruce and hemlock collected at Scarsdale, the small, dull greenish, brown-headed larvae working at the base and mining adjacent needles in a whorl. There was also a minor infestation of *Recurvaria piceaella* Kearfott, the larva of which works in a similar manner in spruce and has been recorded in some numbers from both red spruce and fir in Maine (Johannsen, 1913, p. 32-33).

Spraying with a tobacco soap preparation at standard strength, applied about the middle or latter part of July, would very probably destroy many of the young miners. Since most of the feeding occurs in early spring and the caterpillars enter a number of needles, spraying from the first to the middle of May with arsenate of lead, used at the rate of at least four pounds of the powder to 100 gallons of water is a most promising check upon these annoying and nearly unknown pests.

None of the trees examined had a very large proportion of the needles affected, although this was not true of the small spray noticed above. It is probable that in most cases relatively little actual injury is involved, although ornamentals may be rather seriously disfigured by the somewhat abundant webbing at the base of infested needles and the trees furthermore rendered objectionable by the small caterpillars frequently hanging from threads when nearly full grown.

Argyresthia freyella Walshingham. Cocoons presumably of this species were received under date of June 3, 1925, from Joseph Richards, Boston, Mass., and numbered A3355. One moth was reared June 15, 1925.

Cocoon, length 4 mm, diameter 1.25 mm, silvery gray to whitish, tapering somewhat at both extremities and neatly fastened along the entire length of one side to a branchlet or even to a needle. A few of the cocoons have a peculiar mottled appearance, due to a yellowish brown adherent substance.

Powder-post beetles (*Lyc tus* spp.) and automobiles. The work of powder-post beetles in well-seasoned wood is somewhat common and turns up in many unexpected situations. One of the latest is a complaint of the work of these beetles accompanied by injury to upholstering on one of the high-priced, popular makes of automobiles. There have been in recent years several reports of powder-post beetle work in the trim of apartment houses in New York City. The trouble in every case has been due to the use of sapwood. This should be treated with some preservative before being incorporated into a costly building or an expensive machine because there is no very satisfactory method of handling the problem later, aside from the use of heat, and this simply kills the insects in the wood and does not prevent reinfestation.

Notes on Insect Galls

Choke cherry midge, *Contarinia virginianiae* Felt. Specimens of this gall collected by Edith M. Patch at Orono, Me., and also at Presque Isle were received under date of June 29, 1922, accompanied by the statement that the insect was very abundant at the latter locality and that a squirrel was observed feeding upon the infested fruit and thus cleaning up one tree.

Poison ivy root galls. Typical specimens of the galls of *Dasyneura rhois* Coq. were received under date of September 22, 1924, from L. H. Weld, East Falls Church, Va. These galls are angular, brown, somewhat seedlike swellings with a diameter of about one-eighth of an inch. They occur on the rootlets. It is interesting to note that this insect was first brought to notice in 1895 and apparently the gall has not been seen since that time. An examination of poison ivy roots at Whitehall, Washington county, in October showed this insect to be common in one locality. The species was originally described from Lebanon Springs, Columbia county. It has not been found in other parts of the State, although poison ivy roots in several widely separated localities were examined as opportunity offered.

The above-mentioned sending of *Dasyneura* galls from Mr Weld was also accompanied by a number of much larger root galls, apparently bud swellings arising from the larger roots and approximately one-half an inch in diameter. This is a new gall and the producer has yet to be reared.

Andricus coronus Beutm. The gall of this species was exceedingly abundant upon water oak according to Robert S. Walker, Chattanooga, Tenn., in April 1922. Specimens were also received from J. A. Berly from both Anderson and Greenwood, S. C., accom-

panied by queries which would indicate a considerable degree of abundance, while O. I. Snapp reported the galls as "very bad on water oaks used as ornamentals in Fort Valley, Ga." Apparently this somewhat uncommon gall insect has been unusually numerous in several widely separated localities.

Callirhytis clarkii Bass. Specimens of this very striking gall were collected by Dr H. D. House, May 24, 1922, on *Quercus ilicifolia* occurring on the western edge of Albany. Doctor House stated that the infestation was extremely localized, being confined to one bush and to a branch of another some 300 yards away, although this scrub oak was common in the surrounding area. The specimens collected agree very closely with Bassett's happy comparison to elongated blackberries.

This species does not appear to have been recorded heretofore from New York State, although it is listed by Smith as occurring on *Quercus nana* in the New Jersey district.

Long rose gall, *Rhodites dichlocerus* Harr. A number of specimens of roses, *Rosa rugosa*, were received under date of September 18, 1922, from George N. Sleight, secretary of the board of education, Ironwood, Mich., accompanied by the statement that the roses on the high school and domestic science grounds were badly infested, the stems down to the ground being affected.

An examination of the material showed a very general prevalence of galls, many of them evidently having developed from low, lateral buds. In these cases the growth was frequently about two inches long, irregularly fusiform, with a major diameter of one-half an inch and rather thickly and somewhat coarsely spined. One shoot in the sending showed two dead twigs which had been infested the previous year and a group of three rather stout, lateral bud galls. Another small shoot, about 15 inches long, bore six terminal or subterminal galls, each so located that the bush would be compelled another season to throw out adventitious buds. A stouter shoot bore eight galls which, as in the preceding, were so located as to prevent development another season except from adventitious buds. The infestation was evidently local, since it was stated that no signs of the trouble were evident only a block away, nor on other schoolgrounds in different parts of the city.

This extreme infestation was doubtlessly caused by unusually favorable conditions. The only practical control would be to remove and to burn the infested bushes or parts of bushes. The probabilities are against a continuance of the severe infestation, even if no active repressive measures were adopted.

Miscellaneous

A natural freak: Fifteen-spotted lady beetle, *Anatis quinquedecimpunctata* Oliv. A lady beetle or lady bug, pierced by a pine needle, would seem nearly impossible under natural conditions, yet such a specimen was sent to the State Entomologist under date of July 17, 1924, by Harry D. Longstaff, then at Horicon. The specimen was accompanied with a statement that the insect was alive when found and the needle attached to the pine twig. Moreover, this was on the top of an Adirondack mountain near a cliff and remote from habitations, consequently this odd condition could hardly have been the work of children. An examination of the specimen showed that it had been neatly pierced by the pine needle, a portion approximately one-fourth of an inch long protruding from the under surface. There was no crushing or mangling of the insect such as would have been probable if the beetle had been thrust upon the pine needle by a shrike. The neat entrance and exit of the needle and the color of the beetle showed that it had recently transformed from the pupa to the adult and was therefore presumably in a soft tender condition at the time the branch, swinging in the wind, drove the somewhat old and stiff pine needle through the insect and lifted it from an adjacent support. It is one of the curious accidents which might easily happen and generally escapes notice. A beetle transfixed in this manner might easily live several hours and possibly a day or two.

Nothing of the kind has come to our attention before during some 30 years' study of insect life. This species, both the adults and grubs, feeds on aphids or plant lice and is therefore beneficial.

Crazy ant, *Paratrechina longicornis* Latr. Early in October 1926 our attention was drawn to what appeared to be faint causeless shadows flitting over the floor of a railroad station in Buffalo, N. Y. At first the appearance was thought to be due to tiny midges, especially as cotton moths were also to be seen and the evening was warm. The little creatures were extremely active, running freely forward, backward and sideways apparently with equal facility and appeared to be little more than animated shadows. Specimens were captured and proved to be extremely small, slender ants some three-sixteenths of an inch long with remarkably long legs and antennae. They were kindly identified by Professor W. M. Wheeler as the above-named species. He states that it is a very common tropical ant possibly of Old World origin but now a great nuisance about houses in the West Indies. He believes it to be the "sugar ant" of Linnaeus, since it is very fond of sugar, and adds that it occasionally occurs in heated buildings throughout the year in higher

latitudes. He has noticed them in several buildings in New York City and in the present instance suspects that it is nesting in the woodwork of a nearby restaurant.

R. M. Smith in a list of the ants of Mississippi (1924, p. 122) records this insect from Gulfport and Biloxi, stating that the species infested houses, stores, cafeterias etc., but so far has not been so troublesome as the Argentine Ant. Doctor Wheeler (1919, p. 113) states that this, with several associated species, is everywhere an abundant "Tramp" in the tropics of both hemispheres, and in his volume on the family (1910, p. 156) states that good reasons have been given for believing that the original home of this species is India, it having been carried to all parts of the tropics in ships.

Solitary bees in lawns. These extremely interesting insects, some of them tunneling to a depth of five and even six feet, frequently form colonies of considerable size and occasionally locate in areas where their operations are detrimental. This occurred in July 1922 when a species identified as *Halictus virescens* Fabr. was transmitted from Catskill, N. Y., accompanied by the statement that the bees were destroying a lawn. Bare spots were reported here and there in the lawn and the bees were said to be burrowing more or less over its entire surface although there were areas where they were decidedly more abundant.

In May 1926 our attention was called to a similar condition in a lawn at Loudonville, the insect in this instance being identified by H. L. Viereck as *Andrena regularis* Malloch. Approximately one-fourth an acre of the lawn was infested by the bees, which were decidedly more abundant in areas where the sod was thin and poor. There were practically none in sections where the grass was in excellent condition. It was stated that the bees first appeared upon the lawn some five or six years ago, a date suggesting that the infestation may have followed less attention to keeping the lawn in the best of condition.

The burrows of this bee are marked by small piles of sand, possibly half an inch high and an inch and a half or two inches in diameter, the entrance hole or holes being in or near the center. In some portions of the infested lawn the burrows are within two or three inches of each other, although over most of it the distance is somewhat greater, five and possibly six inches. Calculations based on a photographed area of 300 square inches indicate 376,362 holes to an acre (see figs. 37, 38).

A small yellowish guest bee, identified by H. L. Viereck as most probably *Nomada perplexa* Cress, was observed flying about the infested area. Several specimens were seen, all near the

entrance to the burrows, and two at least repeatedly flew down to the mouth of the burrow and one started to enter. They apparently were looking for favorable opportunities to enter for the purpose of ovipositing in the cells.

A portion of the infested area was dusted rather frequently and freely with grade A calcium cyanide and a number of bees were killed, although this did not usually occur until 10 to 15 minutes after the application. Even repeated puffings of the dust about bees in flight failed to knock them down unless there was an unusually dense cloud.

Watering liberally with a tobacco soap preparation resulted in killing many of the bees at the surface. Some 15 to 30 minutes after the application there were apparently much larger numbers flying over the sprinkled area. These may have been attracted somewhat by the moisture or perhaps driven from or prevented from entering the burrows by the nicotine fumes.

Holly leaf miner, *Phytomyza ilicis* Curtis. The work of this insect was observed at Syosset on Long Island in May 1921 and again came to attention at Westbury in April 1925. In each instance there was a general and somewhat severe infestation. A very considerable proportion of the leaves had the entire upper surface mined and browned by the work of this insect, it being particularly pronounced on the sunny portions of the shrubs. Some of the lower and more sheltered leaves contained only a few of the characteristic serpentine mines. Dull yellowish and brownish larvae were rather common in the affected leaves, indicating these as the normal place of hibernation. The vigor of the shrubs did not appear to be materially affected, although the foliage was badly discolored. This insect appears to have persisted on Long Island for several years and for a time the discoloration of the foliage was supposed to be caused by sun scald. Rearings in 1925 resulted in obtaining a number of flies the latter part of April. It is comparatively easy to determine by examination whether the maggots or pupae still remain in the leaves, in which event remedial measures might be advisable.

The early picking and burning of the affected leaves, especially if thoroughly done, would greatly reduce the numbers of the insect, and if the holly is somewhat isolated, systematic picking year after year might result in the local extermination of the insect. It is quite possible that thorough spraying with a contact insecticide, such as black leaf 40, three-fourths of a pint to 100 gallons of water, to which are added six to eight pounds of soap, would destroy many of the insects before they had an opportunity to escape. Even

better results might be secured from the use of one of the miscible oils, provided foliage injury could be avoided.

Lunate onion fly, *Eumerus strigatus* Fall. This insect is occasionally brought to attention in New York State, and in 1911 a number of infested iris roots from two separate localities in Saratoga were received, from which adults were reared.

Early in 1925 a question arose as to the distribution of this insect in New York State and the possibility of its wintering successfully under our conditions. During July of that season a little collecting in one of the above-mentioned Saratoga gardens demonstrated the somewhat common occurrence of the flies and the possibility of their wintering successfully in that locality. Supplementary collecting resulted in the capture of adults at Amsterdam, Schenectady, Albany, Greenville and Athens in the eastern section of the State, and at Geneva in the central portion. None was found in iris beds at Rochester, East Aurora and Fredonia in the western section of the State and in several localities where there were small numbers of plants in the eastern area. These negative records by no means indicate the absence of the species, since in the brief time then available for collecting it was impossible to make an exhaustive search for the insect and there was always the chance of going to a certain bed at a time when very few or no flies were abroad. Similar collecting in July 1926 resulted in taking flies at Garden City and Westbury, L. I. In none of these cases were the flies definitely associated with material injury to iris.

These preliminary investigations were undertaken in response to an inquiry from Washington authorities as to the distribution of the insect and its ability to sustain itself in this State, the data being preliminary to a consideration of the advisability of imposing quarantine regulations to prevent the importation of bulbs infested by this and other injurious species.

Heliothrips haemorrhoidalis Bouché. Many specimens of this interesting form were received from R. E. Horsey, Rochester, under date of July 24, 1922. He referred to them as curious, reddish insects on fungi, occurring on the European bird cherry, *Prunus padus*.

A specimen of the bark affected by a fungus, *Polyporus* sp., was literally swarming with the thrips in all stages of development from minute, reddish young to fully developed, nearly black adults. They were swarming in cavities of the fungus, possibly feeding thereupon, and apparently were developing in large numbers. A few nearly full-grown individuals occurred upon adjacent bark.

Roaches in city dumps. During the summer of 1924 one of the Hudson Valley cities was compelled to wage an offensive campaign against millions of small croton bugs or water bugs, *Ectobia germanica* Linn., which had established themselves in a city dump and reproduced so freely as to prove a veritable pest to nearby residents. The large cockroach, *Periplaneta orientalis* Linn., as well as the smaller croton bug, is capable of living under such conditions and occasionally becomes a serious nuisance. Both the croton bugs and cockroaches feed upon a great variety of vegetable and animal substances, such as the refuse scraps from the sink, the food on the pantry shelves, prepared cereals, woolens, the leather of stuffed furniture or books, the sizing or paste of cloth-bound books and similar materials. It is easy to realize that certain portions of city dumps might afford very congenial conditions to these insects.

A little care in sorting out materials likely to be attractive to roaches would go far toward reducing the probabilities of a serious infestation. A limited amount of food would not necessarily mean an outbreak of the insects, although unlimited quantities might easily produce such results. It is probable that in most cases prevention of the general character outlined above would be cheaper than direct control measures, although the latter are possible, the precise method depending to a considerable extent upon the size and character of the dump. If the deposit is not too deep, it may be possible and more economical to pull it over and scorch and kill everything living by the use of a giant flame torch. The latter can be improvised from the ordinary extension nozzle of the orchardist, which is little more than a slender iron pipe eight to ten feet long, with an atomizing nozzle, familiar to all sprayers, at the extremity. A pump, hose connection and a supply of any crude oil is all that is necessary. Simply start the pump going and when the spray issues from the nozzle project it on to a flaming piece of paper and instantly there is a very effective blow torch capable of driving a flame three to five feet, much depending on the size of the nozzle and the pressure.

Steaming the pile where possible would also be very effective. It would be necessary to cover it with canvas or some such protective material, in order to insure the requisite penetration.

It is probable that conditions such as the above can be handled more satisfactorily and economically by the use of a new insecticide known as calcium cyanide. It is only necessary to distribute the material rather freely over the dump and many of the cockroaches will succumb from the poisonous gas which is slowly liberated. The treatment can be made more effective by making bar or other holes in the débris and dropping the cyanide well toward the lower limits

of the layer. A thorough treatment throughout the accumulation should result in the destruction of all the insects.

European earwig, *Forficula auricularia* Linn. The occurrence of this insect in New York State was first brought to notice in August 1917 and at the request of Federal authorities an examination of the locality at East Aurora was made in July 1925. This newly introduced insect appears to be thriving in that locality and in the opinion of one resident is generally distributed. An observant greenhouse man stated, however, that he had never seen any although he is within a thousand feet of the premises which were originally infested. The insects are certainly numerous in some places since a hundred or so were observed under the loose bark of an elm log on premises at the corner of Maine and Center streets. The earwigs do not seem to be particularly troublesome aside from the annoyance caused by their invading the house. They are also very apt to alight upon drying clothes and are frequently carried indoors with the laundry.

BIBLIOGRAPHY

Britton, W. E.

1922 European Nitidulid Beetle. *Econ. Ent. Jour.*, 15:311

Britton, W. E. & Friend, R. B.

1924 The Western Corn Root Worm in Conn. A European Leaf Miner of Birch. *Econ. Ent. Jour.*, 17:601

Felt, E. P.

1922 *Ocnerostoma piniariella* Zeller, Another Introduced Insect. *Econ. Ent. Jour.*, 15:432-33

1924 Manual of Tree and Shrub Insects, p. 1-382

1926 Pales Weevil in a New Role. *Econ. Ent. Jour.*, 19:795

Folsom, J. W.

1901 The Distribution of Holarctic Collembola. *Psyche*, 9:159-62

Forbes, W. T. M.

1924 Two Minor Pests from Europe (Lepidoptera, Plutellidae). *N. Y. Ent. Soc. Jour.*, 32:173

Johannsen, O. A.

1913 Two Spruce Leaf Miners. *Maine Agric. Expt. Station Bul.* 210, p. 32-33

Keilin

1924 On a Case of Intestinal Myiasis in Man Produced by the Larvae of a Sarcophagine Fly. *Parasitology*, 16:318-20

Smith, R. M.

1924 An Annotated List of the Ants of Mississippi. *Ent. News*, 35:121-27

Theobald, F. V.

1909 The Insect and Other Allied Pests of Orchard, Bush and Hothouse Fruits, p. 1-550

Wheeler, William M.

1910 *Ants*, p. 1-663

1919 The Ants of Tobago Island. *Psyche*, 26:113



Fig. 34 Enlargement of one of several small larvae of *Wohlfartia vigil* Walk, removed from the human eye, x160.



Fig. 35. Work of European hornet, *Vespa crabro* Linn., in lilac; to the left, recent work; to the right, older work showing exposed dead wood and scarring of the wood surface.

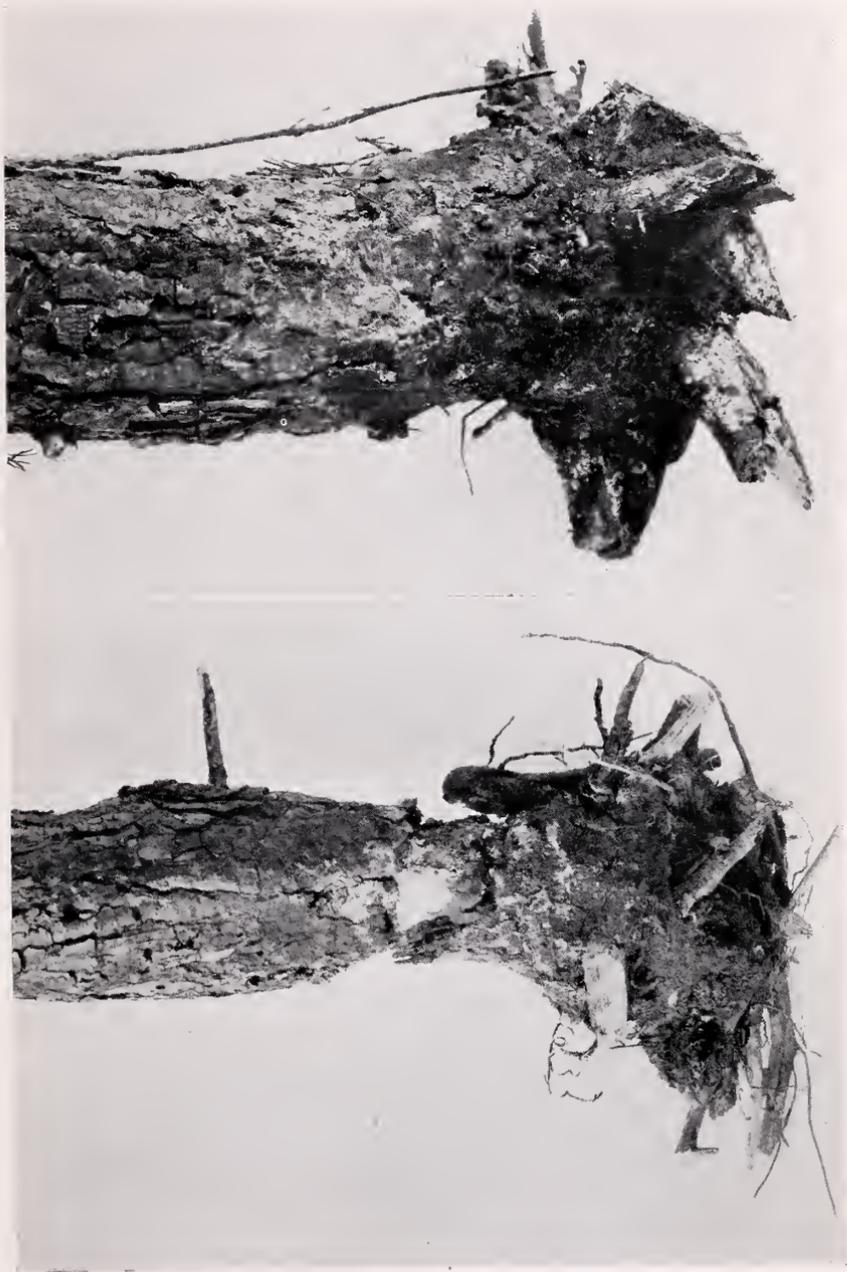


Fig. 36 Work of pales weevil, *Hyllobius pales* Boh., in Scotch pine; to the left a base of a tree some 4 inches in diameter dying in midsummer, note the completely girdled condition just below the surface of the soil. To the right, the base of a tree showing little evidence of injury above ground, note the pitch masses and borings at the very base of the trunk and also on the roots.

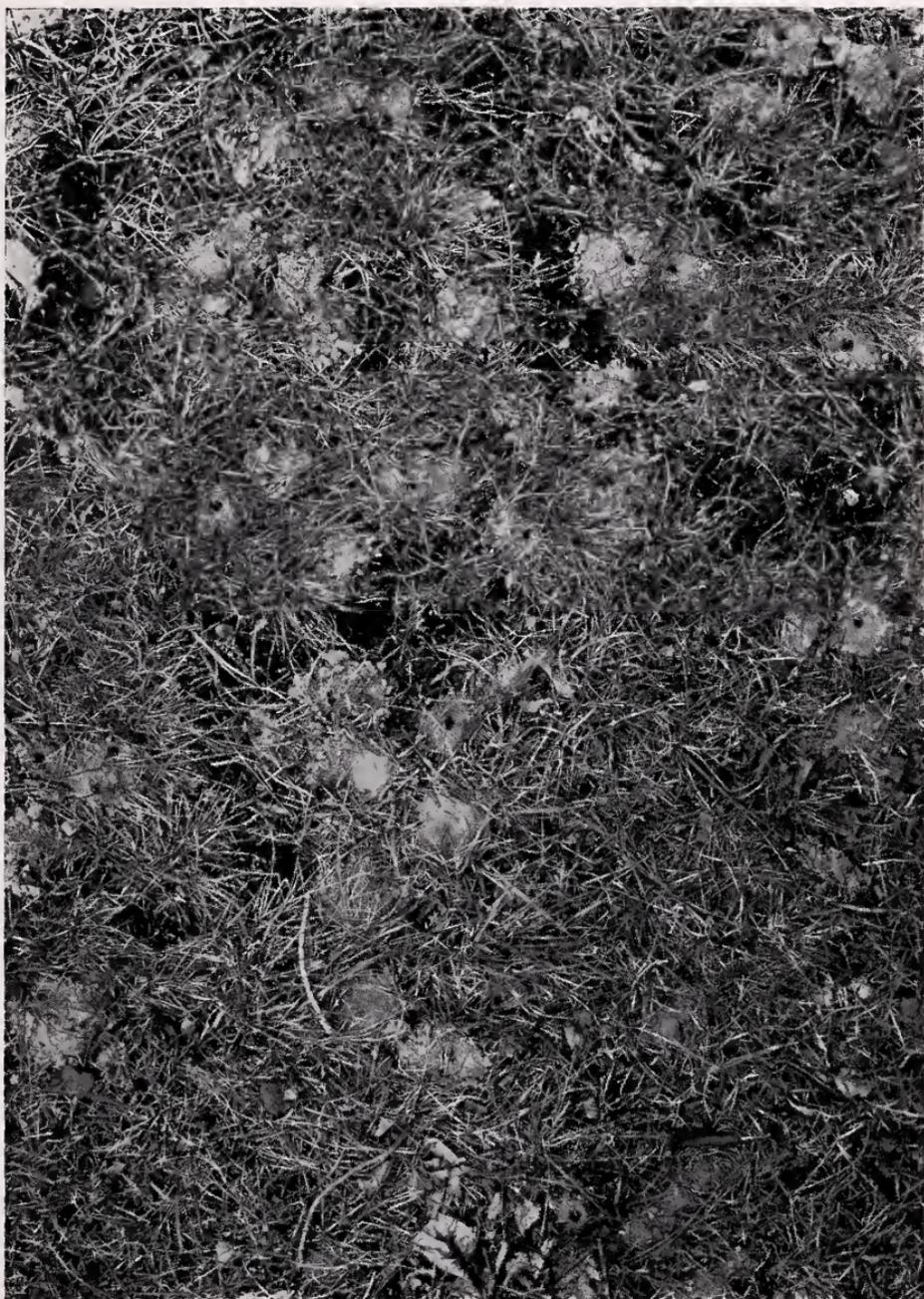


Fig. 37 Portion of a lawn showing the numerous entrances to tunnels excavated by a solitary bee, *Andrena regularis* Malloch., the piles of soil about the galleries are $1\frac{1}{2}$ inches or 2 inches in diameter.



Fig. 38. A view of a lawn infested by a solitary bee, *Andrena regularis* Malloch., more enlarged, the view to the right, moderately enlarged, that to the left more so, showing one pile of earth with two entrance holes.

A REPORT ON THE HYMENOPTERA IN THE NEW YORK STATE MUSEUM

By

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The bees, wasps and their allies, or the Hymenoptera, include a large number of important, though not well known species since they have not been favorites with many collectors. There are large series, for example, of parasites, some of them developing within the limits of microscopic insect eggs, while long series attack various destructive leaf-feeding caterpillars, such as the apple tent caterpillar and the gipsy moth caterpillar, to mention only a few injurious species. The situation is further complicated by numerous hyperparasites which prey upon the beneficial species and are therefore more or less injurious in an indirect way. The relation of parasites to injurious species and the part hyperparasites, parasites of parasites, play in the control of injurious species are relatively new phases of entomology with important economic applications. The biological relations among these insects are very complex and there is much to be learned along these lines.

There are in addition large series of bees and wasps. They are also of great economic importance because they pollinate flowers and thus make possible large crops of valuable fruits. This essential service of insects is all too frequently taken for granted. The honey-bee is one of the better known members of this order.

Excepting the sawflies, Tenthredinoidea, the ants, Formicoidea, the smaller parasites, the Chalcidoidea, and Serphoidea, I have in the course of preparing this report generically verified or determined all the members of the Hymenoptera. To be more explicit, I have up to the present in the preparation of this report examined some six to ten thousand specimens, many of which are now determined to the species in harmony with the views of the best authorities.

In the large group of parasitic forms known as the Braconidae, I have recognized what appear to be new genera and in the even larger series of parasitic forms, the Ichneumonoidea as a whole, I have noticed some species new to science but the positive status of the apparent novelties awaits further investigation.

In order to complete the determination of the Hymenoptera in the New York State Museum collections as well as it can be done at the present time, it will be necessary to send some of the material to specialists at a distance and to compare some of the specimens with types in the large collections of the Hymenoptera in Philadelphia and Washington.

I have found the collection strongest in the bees or Apoidea wherein there are many species determined by that most reliable scientist, Charles Robertson. In the other superfamilies there is a good nucleus toward a more perfect reference collection and I would suggest that special efforts be made toward augmenting the collection of injurious and beneficial Hymenoptera. This recommendation applies particularly to the sawflies or Tenthredinoidea of MacGillivray or the Chalastogastra of Konow, the Ichneumon-flies, Ichneumonoidea, the gall wasps, Cynipoidea, the Serphoidea and the wasps, Vespoidea, the last four superfamilies *sensu* Ashmead, the Serphoidea being the latest name for the large series of minute parasites better known as Proctotrypoidea. (E. P. F. and H. L. V.)

The detailed records in regard to determinations are given below:

Tenthredinidae

Neodiprion sp., Buffalo, July.

Vipionidae

Opius sp., Thacher Park, May 27, 1923; Adirondack Lodge, July 1, 1923; Albany, June 12, 1887; September 18, 1917

Apanteles congregatus Say, Conquest, July 21, 1894; Patria, July 20, 1899; Cranberry Lake, September 14, 1901; Ithaca, August 2, 1892

Reared from a number of hosts. This is one of the commonest parasites of tomato worms and allied sphingid caterpillars, the numerous egglike cocoons forming clusters on the bodies of its victims.

Apanteles glomeratus Linn., Niskayuna, N. Y. October 10, 1885

A parasite of many caterpillars, including the common cabbage worm.

Apanteles tischeriae Vier., Albany, July 1, 1888

Apanteles trachynotus Vier., Wells, July 26, 1923

Apanteles fumiferanae Vier., Ogunquit, Me., June 30, 1914; Orono, Me., June 29, 1914

Reared from a leaf roller, *Archips fumiferana* Clem.

Apanteles cacoeciae Riley, Albany, April 12, 1912

Reared from a lepidopteron, probably *Eucosma scudderiana* Clem.

A. euchaetis? Ashm.

A. crambi? Weed, Albany, June 11, 1899

Apanteles sp., Albany, June 13, 1903

Apanteles sp., Wells, July; Black Mountain, September; Juanita Island, September

Apanteles sp., Poughkeepsie, July; Albany, May

Apanteles sp., Albany, July; Kenwood, July

- Apanteles* sp., Albany, July 11, 1899, June 27, 1903; New Russia, June 8, 1900; Karner, May 14, 1906; June 4, 13, 1901; Denmark, May 24, 1900; Newport, June 23, 1916; Wells, July 12, 1923
- Mirax aspidiscae* ? Ashm., Fishkill, May 4, 1910
- Microgaster brevicauda* Prov. ? Speculator, August 2, 1909
- Microgaster* sp., Albany, June 18, 21, 26, 1899; June 13, 1903; May 8, 1916; Ithaca, July 12, 26, 1892; Wells, July 12, 23, 1923; Clyde, July 24, 1923; Delmar, May 15, 1906; Ilion, May 17, 1902; Karner, May 21, 1902; Newport, May 20, 1902; Trenton Falls, June 21, 1916
- Important parasites of a number of injurious insects
- Microplitis mamestrae* Weed, Albany, August 4, 1899
- Parasite of the zebra caterpillar, *Mamestra picta* Harris
- Microplitis* sp., Albany, June
- Microplitis* sp., Nassau, June 4, 1904; Wells, July 1923; Adirondack Lodge, July 1, 1923; Keene, June 28, 1923; Dug Mountain, August 8, 1912; Albany, June 27, 1903
- Microbracon* sp., Hudson Falls, June 29, July 1, 1914, Reared from *Dryopteris thelypteris* infested by *Phlyctaenia terrealis* Hbn.; Menands, July 10, 1899; Kenwood, May 30, 1903; Karner, May 14, 1906; Albany, May 24, 1906, July 9, 1908, June 27, 1903, April 27, 1907, June 13, 1903, September 7, 1908; Johnstown, August 8, 1907; Wells, July 18, 29, 1914, July 19, 24, 25, 26, 1923; Karner, April 25, 1902, June 18, 1917; Speculator, August 5, 1912; Poughkeepsie, June 2, 1923; Clayville, June 8, 1921; Rochester, 1915; Hoversville, June 20, 1923
- Microbracon sesiae* Museb. ? Albany, June 11, 1912
- Microbracon* sp., Karner, July 4, 1918; Albany, June 27, 1903
- Microbracon* sp., Juanita Island, September
- Microbracon* sp., Broadalbin, June
- Iphiaulax* sp., Wilmington, August 11, 21, 1888; Keene Valley, August 10, 1889; Menands, May 7, 1896; Hudson Falls, April 21, 1915; Speculator, July 17, 1909
- Coeloides ulmicola* Vier., Lawrence, Kans., May; Douglas County, Kans. May 9
- Coeloides* sp., Wilmington, August 17, 1888; Austerlitz, June 8, 1925; Poughkeepsie, June 17, 1903; Boulder, Colo., August 25, 1901; Douglas County, Kans., May 22; Wells, July 31, 1914; Karner, June 4, 1902; Mount Vernon, July 10, 1912; Glenmont, June 14, 1923; Wilmington, August 15, 17, 1888; Piseco Lake, August 30, 1888; Newport, June 30, 1905; Poughkeepsie, July 14, May 20, July 17, 1903; Saranac Inn, August 17, 1903; Storrs, Conn., July 27, 1923; McIntyre summit, July 1, 1923; Big Moose, July 6 to August 13, 1903; Albany, May 18, 1925, May 7, 13, 1924, June 7, 1914

Alysiidae

- Aphaereta dolosa* Vier., Lawrence, Kans., July
- Aphaereta muscae* Ashm., Wells, July 29, 1914, July 12-26, 1923
- Aphaereta* sp., Albany, July
- Cerobracon* sp., Scarsdale, April 19, 22, 1913, Reared from hemlock infested by the hemlock borer, *Melanophila fulvoguttata* Harris; New York, April 22, 1913; Big Moose, July 6, 1903
- Monogonogastra augustus* Vier., ? Albany, June 4, 1908; Poughkeepsie, May 22, 1903
- Monogonogastra* sp., Karner, May 23, 1912; Elm Lake, August 7, 1912
- Coeloidina* sp., Clinton Heights, October 15, 1906

Banchidae

- Banchus spp., Ithaca, June; Broadalbin, June; Lawson's Lake, June; Poughkeepsie, May; Karner, June
 Banchus sp., Karner, June
 Banchus spp., Karner, June; Speculator, August; Remsen, June
 Banchus spp., Poughkeepsie, May; Saranac Inn, June; Old Forge, July

Braconidae

- Schizoprymnus sp., Albany, June 13, 1903; Jamaica Plain, Mass., May 13, 1911
 Reared from a sawfly larva on solidago
 Homolobus sp., Saranac Inn, July 21, 1900
 Amicroplus sp., Nassau, May 19, 25, 30, 31, June 1, 1906; Wells, July 25, 1923, July 29, 1914
 Clinocentrus sp., West Winfield, June 7, 1921
 Symphya sp., Albany, May 24, 1906
 Doryctes sp., Albany, May 18, 1922, May 12, 14, 20, 23, 25, 27, 1903; July 21, 1903
 Xenarcha sp., Aweme, Man., May 16, 1907
 New Genus ? near Brachistes, Albany, July 7, 1903
 Macrocentrus solidaginis Cress., Nassau, July 1, 1905, June 16, 1905
 Reared from a goldenrod gall
 Macrocentrus sp., Wells, July
 Macrocentrus sp., Rochester, June
 Macrocentrus sp., Albany, June 13, 1912; Niverville, May 19, 1911, Reared from apple leaves folded by *Ancylus nubeculana* Clemens; Nassau, June 1, 1906; Poughkeepsie, June 22, 1903; Albany, June 4, 1906
 Ichneutidea secunda Roh., Pompton, N. J., August 14, 1923
 Eubadizon sp., Albany, July 29, 1912
 Reared from *Phyllonoryter hamadryella* Clem.
 Eubadizon sp., Corinth, June
 New genus ? near *Doryctes*, South Hadley, Mass., May 17, 1925
 Meteorus sp., Albany, May
 Meteorus sp., Kenwood, May 30, 1923; Ithaca, June 28, 1892; Albany, July 20, 1888
 Meteorus sp., Saranac Inn, July 21, 1905; Albany, June 24, 1912; July 27, 1888; Northampton, June 25, 1914
 Meteorus sp., Ballston, July
 Meteorus sp., Speculator, June
 Meteorus sp., Hamden, June
Dinocampus americanus Riley, Scotia, August 7, 1910
Orgilus sp., Elm Lake, August 7, 1912
Orgilus sp., Albany, May 21, 1906; Forest Hills, Mass., May 8, 1911; Wells, July 23, 1923
Bassus sp., Karner, May 20, 1903; Central Nassau, July 1, 1920; Fort Lee, N. J., 1907; Albany, June 27, 1903
Bassus sp., Westbury, L. I., July
Bracon sp., Fort Collins, Colo., 1901
Agathis sp., Saranac Inn, July 22, 1905

- Agathis sp., Keene Valley, August 7, 1886; Karner, August 31, 1904; Speculator, August 5, 1912
- Cerobracon sp., Poughkeepsie, May 12, 1910
- Spathius sp., Speculator, June
- Ascogaster carpocapsae Vier., Albany, June 7, 1909, May 3, 1910; Wilmington June 3, 1925; Rochester, June 8, 15, 18, 22, 1925; Windham High Park, June 17, 1923; Troy, June 1912; Clayville, June 8, 1921; Schenectady, June 11, 1923
- A parasite of the apple worm or codling moth, *Carpocapsa pomonella* Linn.
- Chelonella sp., La Jolla, Calif., June 10, 1914; Keene Valley, August 4, 1924; Albany, June 27, 1903; Saranac Inn, July 22, 1905
- Sigalphus bicolor Cress., Albany, May 10, 19, 1891
- Epirhyssalus sp., Albany, May 10, 1907
- Reared from willow cabbage gall, *Rhabdophaga brassicoides* Walsh.
- Aleiodes spp., Lake Louise, B.C., July 19, 1916; Albany, July 11, 1899; Voorheesville, June 19, 1923; Poughkeepsie, June 5, 1903; Wells, July 31, 1914
- Aleiodes sp., Hope, August 29, 1900; Wells, July 19, 1923
- Aleiodes canadensis Cress., Dug Mountain, August 8, 1912; Wells, August 7, 1918
- Hormius sp., July 25, 1923
- Heterospilus spp., New York, May 18, 1912; Mud Hollow Pond, June 20, 1923; Albany, June 5, 1902; Nassau, May 19, 1906; Wells, July 26, 1923.
- Heterospilus sp., Geneseo, April 12, 1902; Roslyn, July 17, 1913
- Heterospilus sp., Geneseo, April
- Heterospilus sp., New York, May 2, 1912
- Reared from hickory log infested with the hickory bark beetle, *Scolytus quadrispinosus* Say.
- Polystenidea, sp. Wells, June 26, 1923
- Colastes sp., Belden Hill, May 19, 1923
- Colastes sp., Wells, July 24, 1923
- Cenostomus ? sp., Newport, June 23, 1916
- Phanerotoma sp., Wells, July 26, 1923, August 3, 1912
- Ichneutes sp., Nassau, May 6, 1902
- Pygostolus ? sp., Albany, October 22, 1900
- Earinus limitaris Say, Albany, April 29, 1906, May 14, 1909, April 3, 1910, April 16, 1916; Karner, April 15, 1902, April 14, 1905; Nassau, April 28, 1903; Delmar, April 30, 1906; Interlaken, April 18, 1918
- Helconidea dentipes Brulle, Albany, May 20, 21, 23, 25, 27, 28, 29, 1903
- Helconidea ligator Say, Greenwich, Conn., March 22, 27, 1915; April 2, 5, 1915
- Reared from hickory infested by *Magdalis olyra* Herbst and *Neoclytus erythrocephalus* Fabr.
- Leiophron sp., Chapel Pond, June 28, 1923
- Diatmetus ? sp., Wells, July 23, 1913; Clayville, June 8, 1921; Meadowdale, October 23, 1907
- Amicroplus ? sp., Nassau, May
- Blacus ? sp., Wells, July 24, 1923

Vanhorniidae

- Vanhornia eucnemidarum* Cwfd., Wells, July 28, 1914

Evaniidae

- Foenus tarsitorius* Say, Canandaigua Lake, July 26, 1894; Lake Pleasant, July 20, 1887; Lake Placid, August 7, 1888; Keene Valley, June 26, 1895, June 29, 1896, August 9, 1893; Long Lake, August 12, 1885; Wells, July 29, 1913; Nassau, June 14, 1906; Speculator, August 1908; Poughkeepsie, August 3, 1903, June 8, 1908; Newport, July 3, 1905, July 17, 1907, June 30, 1905; Ithaca, June 28, 1892; Albany, June 18, 1906
- Foenus incertus* Cress., Long Lake, August 8, 1885; Old Forge, June 15, 1905, June 17, 1905; Canandaigua Lake, July 23, 1894
- Odontaulacus bilobatus* Prov., Scarsdale, March 14, 1912, March 26, 1913; Broadalbin, June 29, 1915; Albany, April 25, 1913; New York, May 12, 1913, April 22, 1913 (A2375); Lake Clear, July 9, 1903
- Odontaulacus abdominalis* Cress., Karner, June 13, 1901; Keene Valley, July 14, 1892; Big Moose, July 3, 1903
- Pristaulacus flavicrurus* Brad., Keene Valley, July 1891
- Pristaulacus niger*, Lake Pleasant, July 20, 1887
- Evania punctata* Br., Albany, July 3, 1913, July 26, 1922, July 3, 1916, June 14, 1920, June 25, 1913, June 13, 1908, August 6, 1908, July 7, 1923, November 17, 1925, July 17, 1903
- Evania urbana* Brad., Washington, D. C., August 9, 1917
- Pammegischia burquei* Prov., Keene Valley, July 24, 1890

Capitoniidae

- Capitonus* sp., Mount Vernon, July 10, 1912; Byron, June 28, 1912; Albany, May 7, 1902, June 10, 1903
- Capitonus* sp., Roslyn, July 17, 1913
- Zavipio* sp., Karner, August 31, 1904

Ichneumonidae

- Aphidius* sp., River Head, L. I., July 20, 1917
Reared from potato aphid, *Macrosiphum solanifolii* Ashm.
- Aphidius* sp., Karner, April; Albany, May, June, August
- Cymodusa* sp., Newport, June
- Cymodusa* sp., Poughkeepsie, May
- Sagaritis* sp., Ithaca, September, Albany, June
- Sagaritis* sp., Johnstown, May; Ithaca, September
- Sagaritis* sp., Speculator, August
- Sagaritis* sp., Central Nassau, July 6, 1920
- Sagaritis* sp., Ithaca July 12, 14, 1892
- Campoplex* sp., Newport, May
- Campoplex* sp., Orient, November
- Campoplex* spp., Speculator, June; Rochester, July; Clinton Heights, July; Karner, May; Albany, July; Ithaca, July
- Campoplex* (*Ischnoscopus*) sp., Albany, July
- Campoplex* spp., Poughkeepsie, June; Speculator, June; Ithaca, July, September; Albany, April, June; Southampton, August
- Campoplex* (*Ischnoscopus*) sp., Southampton, August
- Campoplex* sp., Orient, June

- Campoplex (*Diocetes*) sp., Westchester county, October
 Campoplex (*Ischnoscopus*) sp., Albany, July
 Campoplex spp., Poughkeepsie, July; Karner, July; Albany, June; Ithaca, July
 Campoplex sp., Speculator, June; Albany, June; Kingston, August; Wells, July
 Campoplex spp., Poughkeepsie, June; Clinton Heights, June; Keene Valley, July;
 Albany, June
 Campoplex (*Ischnoscopus*) sp., Hamden, June
 Campoplex (*Ecphora*) sp., Karner, October
 Campoplex (*Ecphora*) sp., Poughkeepsie, August
 Campoplex sp., Ithaca, June
 Campoplex sp., Slingerlands, July
 Campoplex (*Ischnoscopus*) spp., Hamden, June
 Campoplex (*Eulimneria*) sp., Hamden, June
 Campoplex spp., Albany, April, July; Orient, May; Karner, October; Ithaca,
 July
 Campoplex sp., Belle Isle, May
 Campoplex sp., Ithaca, July
 Campoplex sp., Southampton, July
 Reared from larvae of *Schizura concinna* Sm. & Abb.
 Campoplex sp., Albany, July
 Campoplex (*Ischnoscopus*) sp., Albany, July
 Campoplex spp., Lockport, August; Nassau, May; Newport, August; Albany,
 April, June; Ithaca, July, October; Southampton, August; Poughkeepsie,
 May; Binghamton, June
 Campoplex (*Ecphora*) Ithaca, September
 Campoplex (*Ecphora*) Albany, July, September
 Campoplex (*Ecphora*) Wells, August
 Campoplex (*Angitia* or *Diadegma*) sp., Karner June 11, 1912
 Reared from egg cluster of *Polygonia comma* ?
 Campoplex (*Ecphora*) sp., Johnstown, May
 Campoplex (*Ameloctonus*) sp., Ausable Lake, July
 Campoplex (*Ischnoscopus*) sp., Hamden, June
 Campoplegidea sp., Haines Falls, August 17, 1917; Ithaca, July 12, 1892,
 August 2, 1892; Keene Valley, July 27, 1890, July 25, 1894, August 15, 1899;
 Adirondack Lodge, July 13, 1923
 Campoplegidea *crassata* Vier. Var., Albany, June 7, 1912
 Campoplegidea (*Viereckiana*) sp., Poughkeepsie, May
 Campoplegidea sp., Keene Valley, July
 Campoplegidea sp., Ithaca, June 16, 1893
 Campoplegidea *argentius* Nort. ?, Ithaca, June 16, 1893
 Campoplegidea sp., Johnstown, May 20, 1908; Albany, June 17, 1912; Lake
 Placid, June 27, 1911
Viereckiana vitticollis Nort., Poughkeepsie, June 1, July 15, 1914, August 3, 1903,
 June 16, 1904, June 9, 1918; Karner, July 18, 1902; Big Moose, August 13,
 1903, July 7, 1903; Keene Valley, July 16, 1890; Jamaica, L. I., June 24, 1923
Viereckiana villosa Nort., Poughkeepsie, June 22, 1903; May 2, 1904; Albany,
 June 15, 1906; August 22, 1907; Wells, July 8, 1923
Viereckiana sp., Ithaca, August 1892, July 12, 1892; Brant Lake; Wells, July 14,
 1923, August 7, 1918; Poughkeepsie, May 2, 1904; Corinth, June 2, 1916

- (Viereckiana spp.), Albany, September 15, 1894, June 13, 1913
 Idechthis sp., Ithaca, September
 Idechthis sp., Poughkeepsie, June
 Bathyplectes sp., Corinth, June
 Bathyplectes spp., Clinton Heights, June; Albany, June; Broadalbin, June;
 Johnstown, May
 Hyposoter geometrae Ashm., Hamden, June 30, 1924
 Hypothereutes sp., Albany, June
 Eripteroides sp., Speculator, August
 Exetastes suaveolens Walsh, Saranac Inn, July 22, 1905; Speculator, August 1908
 Seleucus sp., Keene Valley, August
 Paracandia elyi Vier., Wells, August 8, 1918; Poughkeepsie, June 22, 1903
 Pristomerus sp., Albany, June
 Porizon ? sp., Karner, April
 Porizon ? sp., Albany, May
 Porisonidea sp., ? Karner, April; Albany, April
 Orthopelma sp., Long Island, January
 Orthopelma sp., Boulder, Colo., April
 Orthopelma sp., Denver, Colo., January
 Orthocentrus sp., Summit Mount McIntyre, July; Wells, July
 Orthocentrus sp., Elizabethtown, August; Albany, May
 Plectiscidea sp., Chapel Pond, June; Wells, July
 Chelonella sp., Williams, Ariz., June
 Cremastus sp., Wells, July 26, 1923
 Cremastus sp., Poughkeepsie, June 9, 1900
 Cremastus spp., Kingston, August 23, 1904; Johnstown, August 27, 1907; Pike,
 June 14, 1906; Albany, April 25, 1903
 Cremastus sp., Karner, June
 Cremastus sp., Buffalo, June
 Mesochorus sp., Albany, September; Newport, June; Wells, October; Piseco
 Lake; Gloversville, August; Karner, June
 Mesochorus sp., Wells, May, July, August; Valley Falls, May; Albany, June;
 Poughkeepsie, May; Corinth, June
 Mesochorus sp., Speculator, July; Wells, July
 Mesochorus sp., Hamden, June
 Paniscus sp., Albany, September 17, 1904, June 18, 1906; Lake Clear, June 6,
 1906; St Ile, June 4, 1906; Newport, July 23, August 8, July 14, 1902; Stamford,
 Conn., May 4, 1914
 Paniscus sp., Wells, July
 Paniscus sp., Johnstown, July 29, 1908; Hague, August 8, 1923
 Erigorgus sp., Ithaca, July 12, 1892; Lake Placid, August 12, 1904, August 2,
 1888; South Brittain, Conn., 1884; Albany, June 16, 1903, June 22, 1923;
 Adirondack Lodge, July 1, 1923; Lawson's Lake, June 23, 1923; Cabin John,
 Md., April 29, 1916; Murray Bay, Quebec, July or August 1878; Wells, July
 25, 1918; Old Forge, July 14, 1905; Keene Valley, August 5, 1894
 Erigorgus sp., Lyons Falls, July 3, 1899; Pike, May 13, 1901; Nassau, April 19,
 1906; Speculator, August 9, 1912; Karner, May 14, 1902; Poughkeepsie, June
 2, 1903; Big Moose, July 3, 1903; Albany, June 13, 1913; Karner, April 13,
 1906; Keene Valley, July 24, 1890, July 30, 1890, August 3, 1892; Mount
 McIntyre Summit, July 1, 1923

- Erigorgus ambiguus* ? Nort., Woodworth's Lake, May 30, 1908; Poughkeepsie, July 17, 1904
- Erigorgus anale* Say, Poughkeepsie, May 20, 1903
- Erigorgus exilis* Prov. ? Glens Falls, July 5, 1899; Bath, May 14, 1901; Nassau, July 8, 1903
- Erigorgus filiforme* Prov. ?, Big Moose, July 7, 1903; Corinth, June 23, 1915
- Erigorgus semirufus* Cress. ? Newport, May 22, 26, 1902; Ilion, May 11, 1902
- Therion* sp., Albany, August 23, 1909; June 19, 1892; Keene Valley, July 20, 1892; Coeymans, July 4, 1898; Essex county, August 6, 1891; Ithaca, July 12, 1892, June 29, 1892; Albany, August 31, 1922; Naples, July 23, 31, 1923
- Therion* sp., Karner, July 2, 1902; Ithaca, September 20, 1892; Big Moose, July 7, 1903; Albany, 1899; Saranac Inn, July 24, 1905; Kinderhook, September 3, 1923; Wells, August 2, 1923, July 29, 1913, July 3, 1914; Lake Louise, B.C., July 19, 1916; Keene Valley, July 25, 1892
- Thyreodon brullei* Vier., Karner, August 29, 1902, July 5, 1906; Canandaigua Lake, July 19, 25, 26, 1894; Cabin John, Md., July 31, 1916; Karner, September 1, 1923; Newport, August 3, 1902
- Thyreodon costale* Cress., Colorado, January 9, 1909, April 8, 1909
- Eremotylus macrurus* Linn., Gloversville, 1906; Fishers Island, March 1914; North Chatham, June 7, 1912; Albany, September 23, 1898, August 1912
- A common parasite of the larger silk worms, such as the *Cecropia* moth, *Samia cecropia* Linn.
- Ophion bilineatum* Say, Chazy Lake, June 28, 1913; Albany, May 17, 1906; Keene Valley, July 31, 1885
- One of the commonest species of this genus. It has been reared from a number of caterpillars.
- Ophion tityri* Pack., Albany, May 15, 1914
- A somewhat common species which has been reared from several caterpillars.
- Ophion* sp., Albany, June 16, 1903, May 15, 1914, May 29, 1914, June 22, 1903, June 13, 16, May 9, July 15, 1903, June 7, 12, May 18, 1906; Karner, May 8, 1902, September 1, 1923, April 25, 1903, May 22, 23, 1912; Cropseyville, June 21, 1899; Ithaca, June 2, 1893, June 15, April 25, 1913; Corinth, June 23, 1915, May 31, 1916; Newport, July 19, 1902; Deer River, May 23, 1900; Nassau, May 25, 1908, May 24, 1906; Poughkeepsie, April 19, 1906; Niverville, May 28, 1914; Valley Falls, May 7, 1921; Karner, May 21, 1902; Albany, May 23, 1906
- Common and valuable parasites of a number of injurious insects.
- Rogas canaliculatus* Prov., Karner, October 4, 1902
- Eniscopilus purgatus* Say, Meadowdale, August 2, 1904; Canandaigua Lake, July 19, 25, 1894; Newport, July 24, 1902, August 18, 1904; Wells, July 18, 1914; Albany, 1899, August 12, 1907; Ithaca, July 26, 1895, July 29, 1905; Wilmington, August 18, 1888; Keene Valley, August 17, 1893; Poughkeepsie, June 17, 1903; Waldorf, June 26, 1906
- A parasite of the army worm, *Cirphis unipuncta* Haw., and a number of other injurious caterpillars.
- Opheltes glaucopterus* Linn., Lake Pleasant, July 22, 1887; Long Lake, August 18, 1885; Keene Valley, August 12, 1898; Elizabethtown, August 26, 1904
- Exetastes* sp., Karner, June
- Cidaphurus* sp., Karner, May
- Nothanomaloides* sp., Elm Lake, August
- Zaplatystoma* sp., Poughkeepsie, June

- Eiphosoma* sp., Canandaigua Lake, July; Poughkeepsie, July
Euceros sp., Ithaca, August
Diplazon sp., Albany, May, June; Phoenicia, August
Diplazon laetatorius F. ?, Albany, May 20, 1895
Diplazon sp., Poughkeepsie, May 20, 1903; Ilion, May 31, 1902
Diplazon scutellaris Cress. ?. Old Forge, July 13, 14, 1905
Diplazon sp., Nassau, June; Sodus Point, August; Speculator, June; Albany, June; Clinton Heights, June; Old Forge, July
Diplazon sp., Kendall, June; Wells, July; Orient, November; Speculator, June; Poughkeepsie, May; Pearl Point, August
Diplazon sp., Albany, August
Exochus sp., Ithaca, August
Ephedrus sp., Karner, April
Helcostizus sp., Albany, May, October; Nassau, May
Phytodietus sp., Karner, May; Old Forge, June
Phytodietus sp., Speculator, August; Poughkeepsie, June; Newport, July
Lissonota sp., Albany, August
Lissonota sp., Speculator, August; Lake Pleasant, July; Karner, June
Lissonota sp., Keene Valley, July 21, 1895
Lissonota varia Cress. Ithaca, September 2, 7, 19, 1892; Saranac Inn, August 8, 1900; Elizabethtown, August 26, 1903; Long Lake, August 6, 1885; Keene Valley, August 4, 1886
Lissonota sp., Saranac Inn., August; Ithaca, July; Nassau, April; Wells, July
Lissonota sp., Karner, September; Storrs, Conn., July
Lissonota americana Cress., Long Lake, August 6, 15, 1885; Keene Valley, August 5, 1894, August 8, 1892, August 6, 1886; Ithaca, September 20, 1892; Speculator, August 9, 1912
Lissonota pluralis Cress. ?, Ithaca, July 26, 1892
Lissonota parva Cress., Orient Point, April 8, 1910; Ithaca, September 19, 1892
Poemenia albipes Cress., Ithaca, July 19, 1892
Itamoplex sp., Newport, July 17, 1907
Glypta sp., Albany, February; Nassau, April
 Reared from *Lepidopterus* gall on *solidago*
Polysphincta slossonae Davis, Chapel Pond, June 28, 1923
Polysphincta sp., Albany, October
Scambus inquisitoriellus Say, Glens Falls, June 30, 1899; Albany, August 10, 1899, July 20, 1899, July 23, 1886; Karner, June 27, 1903; Poughkeepsie, May 20, 1903; Ithaca, July 19, 1892; Keene Valley, July 16, 1891; Nassau, May 16, 1903; Voorheesville, June 20, 1923; Wells, July 29, 1923; Water-vliet Reservoir, August 2, 1923; Ulster Park, June 17, 1922, July 10, 1892, July 19, 1889, July 23, 1886; Ithaca, July 19, 1892
 An important parasite of the apple tent caterpillar and the white marked tussock moth caterpillar. Recorded from a number of hosts.
Ephialtes aequalis Prov., Ithaca, June 28, 1892; Albany, May 28, 1888; Trenton Falls, June 20, 1916; Poughkeepsie, June 5, 1903
Ephialtes pedalis Cress., Glens Falls, June 30, 1899, July 3, 1899; Poughkeepsie, May 2, 1904; Newport, July 3, 1905; Menands, July 10, 1899; Piseco Lake, August 31, 1888; Keene Valley, August 4, 1893; Mount McIntyre, June 30, 1923; Wells, July 25, 1918; Windham High Park, June 17, 1923; Magnolia, Mass., April 4, 1908
 Parasite of several destructive leaf eaters.

Ephialtes sp., Speculator, June; Wells, July; Saranac Inn, July; Ithaca, July; Albany, May, June, July, August, September; Windham High Park, June; Clayville, June; Canton, Mass., April; Corinth, June; Thatcher Park, May; Nassau Lake, September; Johnstown, May; Lake Pleasant, July

Ephialtes sp., Keene Valley, July

Ephialtes sp., Buffalo, July; Squirrel Island, July; Spencerport, February

Ephialtes sp., Johnstown, August 20, 1907; Lake Placid, August 12, 1904

Ephialtes tenuicornis Cress., Newport, May 22, 1902, June 30, 1905; Albany, June 9, 13, 27, 1903, September 14, 1917; Ithaca, July 12, 1892; Speculator, August 2, 3, 1909; Long Lake, August 14, 1885

Itoplectis conquisitor Say, Bainbridge, July 2, 1923; New Russia, July 8, 1915; Buffalo, July 8, 1915; York, Pa., September 9, 1916; Albany, July 19, 1886, June 9, 1903, September 19, 1907, July 15, 1888, June 25, 1909; Newport, July 8, 1905; Nassau, May 6, 1902; Menands, July 10, 1899, Clinton Heights, June 17, 1903; Lyons Falls, July 3, 1899; Slingerlands, June 7, 1900; Poughkeepsie, June 8, 1908; Glens Falls, July 5, 1899; Delmar, June 18, 1900; Slingerlands, June 7, 10, 19, July 20, 1900; Albany, July 1893, September 16, 1902, July 12, 1899, July 23, 1886, July 13, 1887, July 1892, June 7, 1900, July 13, 1889, August 10, 1899; Lyons Falls, July 3, 1899; Glens Falls, June 30, 1900; Ausable Chasm, July 14, 1912; Keene Valley, July 31, 1890, August 4, 1890, July 30, 1890; Chazy Lake, June 28, 1913; Laurens, July 17, 1920; Rochester, June 17, 1925

A common parasite of several destructive leaf-eating caterpillars.

Iseropus coelebs Walsh, Albany 1884; Speculator, August 5, 1912

Calliephialtes sp., June 10, 1903

Reared from ash log infested by *Obrium rubidum* Lec.

Calliephialtes sp., Canton, Mass., April

Reared from galls of *Sackenomyia packardii* Felt.

Xorides sp., Karner, April; Albany, May

Epiurus sp.?, Kenwood, July; Newport, May

Epiurus nigrifrons Vier., Albany, August 8, 1888, June, July, 1893

Epiurus pterophori Ashm., Poughkeepsie, May 21, 1903

Epiurus alborictus Cress., Albany, June 27, 1903

Epiurus indigator Cress., June 5, 1894

Theronia fulvescens Cress., Glens Falls, June 30, 1899; Delmar, June 18, 1900; Pike, June 22, 1901; Albany, July 21, 1899; September 28, 1899; Tacoma, Wash., August 4, 1911

Hyperparasitic on several lepidopterous larvae

Theronia melanocephala Brulle, Albany, September 19, 1916; Wells, July 20, 1912; Poughkeepsie, August 3, 1903; Ithaca, June 24, 1893

Parasite of several lepidopterous larvae and possibly of *Ephialtes pedalis* Cress.

Ichneumon sp., Albany, June

Ichneumon irritator F., Albany, June 1897, May 6, 1903, May 15, 1903; Ithaca, May 3, 1913, May 2, 1913, July 24, 1895; Newport, June 20, 1895

Ichneumon sp., Ithaca, July 7, 19, September 2; Albany, September 16

Perithous pleuralis Cress., Storrs, Conn., July 27, 1923; Ithaca, July 7, 1892, July 19, 1892, August 15, 1892, June 28, 1893; Albany, September 10, 1891

Arenetra nigrita Walsh, Nassau, May 6, 1902

Labena apicalis Cress., Ithaca, June 21, 1893; Ossining, March 21, 1914; Albany, 1894

Labena grallator Say, Ithaca, July 12, 1892; Clear Water, Fla., January 1922

Megarhyssa (*Thalessa*) *lunator* Fabr., Fort Plain, June 14, 1894; Albany, June 4, 1896, June 17, 1900, September 16, 1891, June 25, 1901, June 10, 1903, July 30, 1913, May 18, 1903, May 14, 1903, May 15, 1903, June 1, 1894, July 17, 1900, June 4, 1923, June 14, 1923, September 7, 1891, May 31, 1902, June 1, 1894; Keene Valley, August 20, 1889; Pike, July 4, 1901; Hope, August 29, 1900; Saratoga Springs, July 18, 1923; Cambridge, June 22, 1906; Fort Ann, September 5, 1912; Lockport, September 2, 1924; Fort Edward, June 19, 1925; Glenmont, June 14, 1923; Poughkeepsie, June 4, 1903, June 3, 1903

Common and effective parasite of several wood borers, especially the pigeon tremex, *Tremex columba* Linn.

Megarhyssa greeni Vier., Wells, July 8, 1914; Albany, September 9, 1887, September 22, 1881; Jamaica, L. I., June 24, 1913; Trenton Falls, June 18, 1896; Bath, June 4, 1907; Poughkeepsie, July 15, 1903

Megarhyssa nortoni Cress., Irvington, May 28, 1901; Newport, June 15, 1895

Megarhyssa atrata F., Nassau, June 22, 1906; Charlotteville, June 14, 1910; Nyack, June 19, 1911; Irvington, July 26, 1900; Albany, June 19, 1900, June 4, 1923, June 29, 1893, June 14, 1923, June 25, 1901, June 17, 1902; Rackett River, June 22, 1897; Glenmont, June 14, 1923; Mayville, 1903; Norwich, June 20, 1923; Saratoga Springs, June 12, 1899, June 18, 1923; Poughkeepsie, May 22, 1903; Saranac Inn, June 17, 1900; Delmar, August 12, 1922; Lockport, June 17, 1912, September 2, 1924

Somewhat common parasite of several wood borers, especially the pigeon tremex, *Tremex columba* Linn.

Rhyssa persuasoria Linn., Saranac Inn, July 19, 1900; Nassau Lake, September 3, 1923

It has been reared from *Monochamus confusor* Kirby and has been recorded as a parasite of *Sirex*.

Rhyssa lineolata Kirby, Gloversville, September 1906; Wells, July 30, 1913

Arotes decorus Say, Poughkeepsie, July 17, 1903; Albany, June 5, 8, 1903, May 28, 1903; Poughkeepsie, August 3, 1903

Arotes venustus Cress., Long Lake, August 12, 1885; Ithaca, July 19, 1895

Arotes amoenus Cress., Keene Valley, July 29, 1895, July 10, 1890, August 5, 1899; Canandaigua Lake, July 13, 1894; Newport, July 3, 1905; Saranac Inn, July 17, 1900; Big Moose, July 7, 1903; Lake Placid, July 10, 1903; Albany, June 15, 1911; Wells, July 16, 1922

Coleocentrus rufus Prov., Poughkeepsie, June 1, 1903

Gelis sp., Schenectady, June

Gelis sp., Karner, June

Gelis sp., Chapel Pond, June; Enfield Glen, August

Mesostenidea sp., Ithaca, July 7, 19, 26; Albany, August

Mesostenidea thoracica Cress., Trenton Falls, June 22, 1916, June 21, 1916; Thatcher Park, Albany county, May 27, 1923; Poughkeepsie, May 21, August 3, 1903; Ilion, May 31, 1902; Ithaca, July 12, 1892; Kenwood, June 2, 1902

Parasite of *Papilio thoas* Linn. and *Anisota senatoria* Fabr.

Mesostenidea sp., Speculator, June

Acronicus junceus Cress., Maynard, Mass., May 13, 1909

- Cryptus extrematus* Cress., Cabin John, Md., June 25, 1917
Parasite of apple tent caterpillar and of cecropia moth
- Cryptus* sp., Old Forge, June
- Polytribax* sp., Poughkeepsie, August; Canandaigua Lake, July
- Itamoplex americanus* Cress., Northampton, June 24, 1914; Lake Placid, August 4, 1888
- Agrothereutes* sp., Newport, June; Poughkeepsie, May, July, August; Albany, June; Speculator, June; Keene Valley, June, July; Corinth, June; Trenton Falls, June
- Agrothereutes* sp., Wells, July; Trenton Falls, June; Poughkeepsie, May, June, August; Albany, June; Nassau, April, May
- Agrothereutes* sp., Newport, June; Albany, May, June, September; Speculator, June; Wells, July; Corinth, June; Nassau, June; Karner, July; Clinton Heights, April; Poughkeepsie, June, August; Ilion, May; Keene Valley, July; Big Moose, July; Canandaigua Lake, July; Adirondack Lodge, July; Gloversville, June
- Agrothereutes* sp., Albany, June
- Thysiotorus smithi* Cushman, Hamden, June 30, 1924
- Phygadeuon* sp., Speculator, June; Wells, August; Ithaca, July; Poughkeepsie, May, June; Karner, May; Newport, May, July; Corinth, June; Valley Falls, May; Kenwood, May; Sacandaga Park, August
- Phygadeuon* sp., Lake Placid, August; Wells, August; Karner, May; Poughkeepsie, August
- Phygadeuon* sp., Nassau, June, July; Gloversville, April; Adirondack Lodge, June; Albany, May, June; Trenton Falls, June; Corinth, June; Ravena, June; Ithaca, July; Broadalbin, June; Poughkeepsie, April, July; Karner, June, Wells, July; Saranac Inn, July
- Glyphicnemis* sp., Newport, July
- Hemiteles areator tenellus* Say, Northampton, June 24, 1914; Corinth, July 1, 1915; Albany, May 3, 1895, June 10, 1887
Parasite of *Papilio thoas* Linn. and *Anisota senatoria* Fabr.
- Hemiteles tenellus* Say, Hamden, July 3, 1924, June 30, 1924
Parasite of *Papilio thoas* Linn. and *Anisota senatoria* Fabr.
- Hemiteles* sp., North Creek, August; Nassau, April; Albany, March, June
- Hemiteles* sp., No locality
- Hemiteles* sp., Wells, July, October; Nassau, May
- Hemiteles* sp., Nassau, May; Newport, June; Chapel Pond, June; Wells, July; Albany, May, June, August; Boston, Mass., June; Speculator, June; Karner, June; Poughkeepsie, June; Karner, May; Cranberry Creek, June
- Toxophoroides* n. sp. ?, Poughkeepsie, June 9, 1908
- Eupelmus* sp. ?, La Pointe, Utah, July
- Phaeogenes* sp., Gloversville, September
- Phaeogenes helvus* Cress. ?, Ithaca, September 7, 1892
- Phaeogenes* spp., Wells, July; Ithaca, July; Albany, May
- Phaeogenes* sp., Poughkeepsie, June; Keene, June; Delmar, May; Newport, June; Pike, April, May; Nassau, June; Sacandaga Park, August; Albany, May; Wells, October; Ithaca, July; Newport, May; Albany, June, July
- Phaeogenes* sp., Ithaca, August; Albany, July, June; Ithaca, July; Speculator, June
- Phaeogenes* spp., Ithaca, August 1892; Clinton Heights, May 6, 1903; Trenton Falls, July 25, 1907

Trogus vulpinus Grav., Karner, June 5, 1905, July 4, 1918; Nassau, May 31, 1902; June 14, 1905; Nassau Lake, May 31, 1902; Lawson's Lake, June 23, 1923; Gloversville, July 13, 1908; Wells, July 16, 1916; Albany, September 8, 1921

Parasite of caterpillars of swallow-tail butterfly.

Trogus sp., Canandaigua Lake, July; Gloversville, September

Amblyteles sp., Albany, August

Amblyteles spp., Gloversville, September; Pike, May; Wells, August, July; Albany June, September; Nassau, May; Speculator, August; Trenton Falls, June; Poughkeepsie, June; Ilion, May, June

Amblyteles sp., Poughkeepsie, May; Pike; Karner, September; Newport, May, July, August; Scotia, June; Bath, March, April; Johnstown, April; Albany, June; Kenwood, July

Amblyteles comptus Say, Keene Valley, August 2, 1894; Poughkeepsie, June 5, 1903; Bath, July 9, 1902; Naples, July 31, 1923

Amblyteles confirmatus Cress., Bath, March 15, 1903; Normanskill, April 18, 1903

Amblyteles navus Say, Gloversville, June 20, 1923; Ithaca, July 14, 1892

Amblyteles sp., Newport, July; Albany, June, October

Amblyteles apertus Cress., Albany, July 2, 1906, July 8, 1905, June 20, 1880

Amblyteles excultus Cress., Albany, June 2, 1889

Amblyteles bronteus Cress., Old Forge, July 15, 1905

Amblyteles centrator Say, Bath, March 15, 1903; Albany, April 4, 1920; Thatcher Park, Albany county, May 27, 1923; Ithaca, March 30, 1913, April 2, 1913

Amblyteles cinctitarsus Prov., no locality

Amblyteles spp., Tannersville, June; Wells, July; Lake Placid, August; Speculator, July, August; Wappingers Falls, June

Amblyteles spp., Lake Placid, August; Phoenicia, August; Cranberry Creek, June; Albany, April, August, September; Poughkeepsie, May, June; Trenton Falls, June; Stockport, July; Valley Falls, April; Wells, July; Ithaca, July; Poughkeepsie, May; Karner, September; Johnstown, March, April, August; Austerlitz, May; Greenville, April; Gloversville, March, August; Glens Falls, July; Voorheesville, June, November; Ithaca, March; Canandaigua Lake, July; Newport, July; Lake Placid, June; Trenton Falls, June; Keene Valley, July; Piseco Lake, August; Ilion, March; Northampton, June; Corinth, June; Watervliet Reservoir, August 2

Amblyteles milvus Cress., Canandaigua Lake, July 13, 1894; Albany, June 26, 1912

Amblyteles mimosus var. *inbellus* Cress., Colorado Springs, August; Essex county, August 6, 1891

Amblyteles succinctus Brulle, Albany, September 16, 1902; Orient, September 3, 1923

Amblyteles mendax Cress., Pike, March 1902; Bath, March 15, 1903; Gloversville, March 29, 1907; Normanskill, April 18, 1903

Amblyteles subcyaneus Cress., Poughkeepsie, July 15, 1903, July 14, 17, May 21, June 1, 8, May 2, 1904, May 22, 1903, July 16, 1903

Amblyteles sp., Pike, May; Johnstown, May; Severance, August

Amblyteles unifasciatorius Say, Ithaca, September 15, 1892; Johnstown, August 10, 1908; Wells, August 5, 1918; Albany, July 13, 1906; Karner, June 2, 1905; Poughkeepsie, July 17, 1903

Parasite of *Apatela oblinita* Sm. & Abb.

- Amblyteles improvisus* Cress., Dug Mountain, August 8, 1912; Ithaca, June 28, 1892; New Baltimore, August 16, 1912; Albany, August 12, 1912; Richmond, S. I., June 16, 1923
- Amblyteles flavicornis* Cress., Newport, July 3, 1905; Bath, July 8, 9, 1902; Albany, August 10, 1899; Wells, July 29, 1913, July 27, 1914; Keene Valley, July 16, 1894; Poughkeepsie, July 16, 1903
- Amblyteles vittafrons* Cress., Saranac Inn, July 21, 1905
- Amblyteles grandis* Brulle, Canandaigua Lake, July 20, 1894
- Amblyteles quadrizonatus* Vier., Albany, September 17, 1904
- Amblyteles jucundus* Brulle, Ithaca, July 19, 1892, October 10, 1892; Pike, June 1, 1901; Karner, May 21, 1902; Albany, August 5, 1924; Gloversville, March 23, 1907
- Platylabus* sp., Speculator, June
- Cylloceria* sp., Corinth, June; Speculator, June; Poughkeepsie, July

Ibalidae

- Ibalia maculipennis* Hald., Poughkeepsie, May 21, 1903, June 1, 1903; Port Chester, September 24, 1913; Albany, June 4, 1923
- Issued from dead wood of injured sugar maple, parasite of a wood borer.

Entedontidae

- Closterocerus* sp., Hicksville, June

Elasmidae

- Elasmus* ?, Binghamton, May 20, 1900

Pteromalidae

- Pteromalus* sp., Phoenix, Ariz., May; New Russia, June
- Dibrachys boucheanus* ?, Spencerport, February 23, 1918
- An important common hyperparasite reared from tent caterpillar and *Cecropia* cocoons.

Eupelmidae

- Eupelmus* ? sp., Speculator, August
- Metapelma spectabilis* West, Ilion, June 10, 1912; Albany, May 7, May 11, 1903

Callimomidae

- Ormyrus* sp., Hoversville, June
- Ormyrus* sp., Karner, July
- Monodontomerus dentipes* Boh., Farmingdale, July 30, 1923
- Reared from pine sawfly, *Diprion* sp.
- Monodontomerus* sp., Rochester, April 12, 1918
- Syntomaspis* sp., Durango, Colo.
- Syntomaspis* sp., Sedalia, Colo., May
- Brachistes* sp. ? Buffalo, May

Eurytomidae

- Eurytoma* sp., Hudson Valley, May 14, 1917
- Reared from gall of *Diastrophus radicum* Bass.

Perilampidae

Perilampus sp., Westbury, L. I., August 7, 1917

Reared from *Archips fervidana* Clem.

Perilampus sp., Albany, August, October

Chalcididae

Chalcis microgaster Say, Berlin, Mass., May 1, 6, 12, April 10, 27, June 7, 1899;

Albany, May 18, 28 29, June 7, 1899; Greenwich, Conn., March 26, 31, 1915

Leucospidae

Leucospis affinis, Canandaigua Lake, July 12, 19, 23, 1894; Karner, August 29, 1902; Newport, June 30, 1905

Has been reared from nests of leaf cutter bees.

Scelionidae

Telenomus sp., Rochester, January

Ceraphronidae

Megaspilus sp., Chapel Pond, June

Serphidae

Serphus sp., Wells, July

Serphus sp., Hope, August

Peleciniidae

Pelecinus polyturator Dru., Stottville, October 5, 1900; Coeymans, 1894; Canandaigua Lake, July 25, 1894; Keene Valley, August 2, 1895, August 7, 1896, August 10, 1889; Lake George, August 19, 1817; Karner, August 29, 1902; Albany, September 3, 1916, September 14, 1916; Ithaca, August 6, 1915; New Russia, August 24, 1925; Nassau Lake, September 3, 1923

Recorded as a parasite of white grubs, of May or June beetles.

Chrysididae

Notozus ? sp., Wells, July

Scoliidae

Scolia bicincta Fab.

Campsomeris plumipes Dru.

Elis quinquecincta Fab., Albany, July 12, 1899; Sheepshead Bay, August 26, 1903

Plesia sp., Albany, July

Tiphia inornata Say, Albany, June 13, 1903; Meadowdale, August 2, 1904; Wells, July 18, 1923; Newport, August 18, 1904

A parasite of white grubs.

Tiphia sp., New Baltimore, August; Poughkeepsie, May, June; Albany, May, June; Karner, May, August; Johnstown, August

Notoglossa sp., Old Forge, July 15, 1905; Wells, July 30, 1912

Sapygidae

Sapyga sp., Albany, May

Methocidae

Methoca stygia Say, Wells, July 29, 1913; Broadalbin, June 29, 1915

Psammocharidae

Ceropales sp., Wells, July 27, 1911

Ceropales bipunctata Say, Newport, August 18, 1904; Johnstown, August 28, 1908

Ceropales fraternus, Saranac Inn, July 22, 1905; Old Forge, July 14, 17, 1905; Keene Valley, August 5, 1896, July 28, August 9, 1892

Episyrion biguttatus Fab., Canandaigua Lake, July 12, 1894; Minerva, August 4, 1885; Keene Valley, July 21, 1893; Wells, July 30, 1912; Gloversville, July 22, 1906

Episyrion quinquenotatus Say, Albany, June 18, 1906; Elm Lake, August 7, 1912; Newport, July 17, 1907; Wells, July 20, 1912

Pompiloides marginatus, Newport, July 8, 1905; Albany, July 13, 1906; Old Forge, July 8, 1905; Sheepshead Bay, July 29, 1889; Keene Valley, August 8, 1895; Jamaica, L. I., July 7, 1923

Cryptocheilus fulvicornis, Sheepshead Bay, August 26, 1903

Psammochares sp., Wells, July 30, 1912, July 31, 1918, August 7, 1918

Eumenidae

Eumenes fraternus Say, Lake Pleasant, August 3, July 29, 1887; Speculator, June 13, 1922; Keene Valley, August 5, 1889, July 31, 1896, July 27, 1887; Poughkeepsie, May 2, 26, 1904; Wells, July 25, 1912; Albany, August 11, 1907, July 6, 1906; Long Lake, August 17, 1885; Wilmington, August 18, 1888

A common potter wasp.

Monobia quadridens Linn., Nassau, September 8, 1902; Albany, July 6, 1906, June 13, 1896; Poughkeepsie, July 1913

Symmorphus walshianus Sauss., Saranac Inn, July 22, 1905; Old Forge, July 13, 1905

Odynerus sp., Karner, June; Keene Valley, August, July; Davidson's R., N. C., September; Albany, August, June; Newport, July; Wells, July; Broadalbin, June

Odynerus megaera, St Farg., Cabin John, Md., June 1917

Odynerus sp., Davidson's R., N. C., September; Wells, July, August; Crosby May; Newport, June; Minerva, August; Kenwood, July; Canandaigua Lake July

Odynerus sp., Crosby, May

Odynerus sp., Wells, July

Odynerus sp., Morgantown, W. Va., July

Ancistrocerus capra Sauss., Piseco Lake, August 21, 1888; Adirondack Lodge, July 14, 1923; Long Lake, August 20, 1885; Albany, June 28, 1894; Keene Valley, August 29, 1888, July 1, 1895, August 8, 1893; Lake Placid, August 4, 1888; Old Forge, June 30, 1905; Bath, May 26, 1911, June 4, 1907; Albany, June 1, 1906, July 22, 1887; Ithaca, June 17, 1893

Ancistrocerus sp., Davidson's R., N. C., September; Piseco Lake, August; Keene Valley, August; Old Forge, July, June; Wells, July; New Salem, June; Albany, July; Nassau, June; Speculator, July; Chazy Lake, June; Minerva, August; Valley Falls, May

Ancistrocerus catskillensis Sauss., Poughkeepsie, May 2, 1904; Keene Valley, July 1, 1895, July 21, 15, 1892, July 18, 1895, July 3, 1892, June 23, 1895; Saranac Inn, July 20, 22, 1905.

Ancistrocerus sp., Keene Valley, July; Bath, June; Ithaca, August; Canandaigua Lake, July; Albany, June, August, September; Orient, September; Poughkeepsie, May; Old Forge, July; North Chatham, June; Corinth, June; Newport, July

Ancistrocerus spinolae Sauss., Lawson's Lake, June 23, 1923

Vespidae

Paper wasps

Vespula diabolica Sauss., Cranbrook, B. C., September 12, 1910; Keene Valley, August 1, 1895

Vespula sp., Keene Valley, August 6, 1895, August 20, 1889; Karner, July 24, 1903; Albany, July 30, 1903; Wells, July 27, 1919; Menands, November 2, 1899; Floodwood, September; Coeymans, June

Vespula sp., Grandfather, N. C., October

Vespula sp., Lake Louise, B. C., July

Synagris ? sp., Philippine Islands, 1916

Polistes variatus Say, Boulder, Colo., August 25, 1901

Polistes sp., Bermuda Islands, March 12, 1897

Sphecidae

Thread-waisted wasps

Nysson sp., Keene Valley, August

Cryptocheilus unifasciata Albany, August 12, 1907

Agenia sp., Wells, July; New Russia, July; Delmar, May; Poughkeepsie, June

Euspongus bipunctatus Say, Albany, April 29, 30, 1912; Douglas county, Kans., July

Hoplisis phaleratus Say ?, Piseco Lake, August 30, 1888; Keene Valley, August 21, 1894, August 2, 1899, July 17, 1894; Minerva, August 4, 1885; Speculator, August 9, 1908; Wells, July 25, 1918, August 11, 1923, August 1, 1923, July 30, 1923, July 20, 1912, July 18, 1914, July 29, 1923; Albany, July 13, 1906, July 25, 1903; Karner, July 24, 1903; Clyde, July 27, 1923

Hoplisis sp., Albany, August

Hoplisis sp., Piseco Lake, August; Albany, August

Hoplisis sp., Wells, July

Mimesa sp., Poughkeepsie, July; Albany, August; Keene Valley, August; Broadalbin, June; Albany, May; Long Lake, August

Oxybelus sp., Wells, August

Oxybelus quadrinotatus Say, Karner, July 23, August 9, 1901; Broadalbin June 29, 1915; Wells, July 30, 1912; Old Forge, July 13, 14, 15, 1905; Carlisle, Pa., August 12, 1918; Bath, May 26, 1911

Notoglossa sp., Karner, July

Notoglossa sp., Kenwood, July

Anacrabro ocellatus Pack., Karner, July 23; Kenwood, July 5, 1900; Speculator, August 1908; Albany, August 12, 1899; Wells, June 29, August 1, 1923

Rhopalum sp., Speculator, June

Solenius sulcus Fox, Albany, June 3, 1912

Solenius sp., Keene Valley, July; Wells, July, August; Long Lake, August; Lake Placid, August; Speculator, June, August; Newport, July; Piseco Lake, August; Nassau, June; Albany, June; Newport, June

- Solenius* sp., Albany, June, May
Solenius sp., New Salem, June
Solenius stirpicolus Pack., Poughkeepsie, June 3, 4, 1903
Crabro sp., Wells, July, August; Boulder, Colo., May; Bath, May; Phoenix, Ariz., April; Karner, June; Pompton, N. J.
Aphilanthops sp., Wells, August
Philanthus sp., Albany, September, June; Wells, July; Keene Valley, August; Karner, July
Philanthus sp., Wells, July
Trypoxylon albitarse Fab., Clinton Heights, April 14, 1900
Trypoxylon sp., Mud Hollow Pond, June
Trypoxylon sp., Albany, May 15, August 5, 1907
Trypoxylon albopilosum Fox, Albany, August 7, 1899
Trypoxylon texense, Plano, Tex., June 1907
Trypoxylon clavatum Say, Ithaca, August 8, July 6, 1899, July 21, 1892
Trypoxylon frigidum Sm., Old Forge, July 13, 1905; Albany, May 15, 1907, June 14, 1908, May 24, 1906, June 13, 1903; Poughkeepsie, June 9, 1908; Ilion, May 31, 1902; Karner, May 5, 1903; Chapel Pond, Essex county, June 28, 1923; West Winfield, June 7, 1921
Trypoxylon carinifrons Fox, Plano, Tex., August, September, 1907
Trypoxylon tridentatum Pack., Karner, July 23, 1902; Ithaca, July 18, 1893; Poughkeepsie, July 17, 1903; Lockport, August 6, 1917
Trypoxylon sp., France, March 1926
Diodontus sp., Zabriskie Coll.
Chlorion ichneumonium L., Karner, September 22, 1902; Albany, July 22, 1919, July 4, 1900; Orient, April 1913; Rensselaer, July 30, 1912; New Russia, September 8, 1901
Chlorion auripes Fern., Karner, August 9, 1901
Chlorion harrisi Fern., Douglas County, Kans., May
Chlorion pennsylvanicum L., N. Y. S. Coll.
Chlorion cyaneum Dahlb., N. Y. S. Coll.
Sphex sp., Voorheesville, August; Davidson's R., N. C., September; Mineola L. I., July; Wilmington, August; Piseco Lake, August; Keene Valley, August; Wells, July; Lake Pleasant, July
Sceliphron cementarium Dru., Canandaigua Lake, August 25, 1920; Wells, July 20, 1914; Coeymans, 1890
Chalybion caeruleum Linn., Pike; Keene Valley, July 17, 1920; Ithaca, July 12, 1892; June 28, 1892; Albany, June 24, 1893, July 2, 1886, July 9, 1915, June 24, 1914; Orient Point, July 12, 1910; Central Nassau, July 6, 1920; Coeymans, June 23, 1899; Karner, August 20, 1902; Irvington, July 26, 1900; Schenectady, June 30, 1920
Lyroda subita Say, Wells, July 7, 1923
Tachytes sp., N. Y. S. Coll.
Tachysphex sp., Karner, July
Psammophila luctuosa Sm., Keene Valley, August 8, 1896; Gloversville, September 5, 1908; Keene Valley, August 15, 1899, July 31, 1886, August 8, 1896; Wells, July 31, 1914; Saranac Inn, July 21, 1905; Lake Pleasant, July 26, 1887; Lake Clear, July 9, 1903
Pemphredon sp., Wells, July

Euceridae

Melissodes bimaculata Le P., Amsterdam, July 17, 1925

Bembecidae

Sphecius speciosus Dru., Douglas county, Kans., July; Albany, August 28, 1900, July 15, 1901; Karner, August 9, 1901, August 20, 1902, July 15, 1901

A large southern form, occasionally making numerous large burrows in lawns, known as the "Cicada killer" because harvest flies are favorite victims.

Microbembex monodonta Say, Karner, July 19, 1900; August 1, 1902, June 29, 1910; Albany, July 7, 1887; Keene Valley, August 4, 1893; Menands, July 13, 1922; Wells, July 19, 1923

Bicyrtes quadrifasciata Say, Menands, July 13, 1922

Bicyrtes ventralis Say, Keene Valley, August 7, 1895; Albany, July 30, 1900; Newport, June 30, 1905

Bicyrtes sp., Keene Valley, August; Karner, June

Bembix spinolae St Farg., Keene Valley, August 10, 1895, July 27, 1894, August 11, 1893, August 9, 1886, August 10, 1889, August 13, 1891, August 10, 1892, August 1, 1894, August 17, 1893, August 2, 1890; Piseco Lake, August 29, 30, 1888; Lake Pleasant, August 3, 1887; Hatch Ex. Station, August 17, 1901; Karner, July 24, 1903; September 6, 1901, July 27, 1901, August 4, 1902, July 24, 1903; Saranac Inn, August 4, 1900; Severance, July 18, 1897; Newport, July 8, 1905; Wells, July 19, 1923

Stictiella emarginata Cress., Center, July 28, 1870

Cerceridae

Cerceris deserta Say, Cabin John, Md., June 1, 1918

Cerceris sp., Wells, July, August; Keene Valley, August; Albany, August; Karner, September; Old Forge, July; Poughkeepsie, June, July, August

Halictidae*Solitary or digger bees*

Halictus sp., Wells, July

Halictus provancheri D. T., Kenwood, May 30, 1923; Clyde, July 12, 1923; Wells, August 1, 1923; Franklinton, June 20, 1923; Mineola, July 8, 1923; Valley Falls, May 8, 1921

Halictus ligatus Say, Clyde, July 27, 1923; Mud Hollow Pond, June 20, 1923

Halictus lerouxi LeP., Wells, July 8, 1923

Halictus spp., Wells, July; Hague, August; New Salem, June; Voorheesville, August; Adirondack Lodge, July; Orient, May; Mineola, July; Tompkins Corners, July; Normanskill, August; Wappingers Falls, June; Rensselaer, May; Thompson, May

Sphecodes sp., Wells, July

Andrenidae*Solitary or digger bees*

Andrena sp., Albany, June

Andrena canadensis D. T., Piseco Lake, August 30, 31, 1888; Keene Valley, August 13, 1889; Gloversville, August 18, 1908

Andrena moesta Sm., Gloversville, August 20, 1908

Andrena sp., Mineola, June; Nassau, May; Mount McIntyre, July; Wells, April; Valley Falls, May; Orient Point, May; Albany, June; Keene Valley, July; Center, 1885; Newport, July

Andrena crataegi Rob., Wells, May 8, 22, 1921; Keene Valley, June 14, 1892; Nassau, May 16, 1903; Valley Falls, May 8, 1921

Andrena erythrogaster Ashm.

Andrena clarkella Kirby, Center, April 21, 1885

Andrena integra Sm., Gloversville, July 21, 1917

Andrena salictaria Rob., Thompson, May 25, 1923

Andrena illinoensis Rob., Long Lake, August 1885

Andrena wilkella Kirby, Gloversville, June 28, 1917

Macropidae

Macropis sp., Wells, July

Panurgidae

Panurginus cressoniellus Ckll., Florissant, Colo., July 29, 1907

Calliopsis andreniformis Sm., Saratoga, July 14, 1925

Nomadidae

Nomada sp., Keene Valley, August

Epeolus sp., Voorheesville, August

Hylaeidae

Hylaeus sp., Speculator, June; Hague, August; Mineola, July; Marlboro, June; Albany, July; Clayville, June

Hylaeus sp., Trenton Falls, June

Phanerotoma sp., Albany, July 8, 1908

Megachilidae

Leaf cutter bees

Megachile sp., Adirondack Lodge, July; Wells, August

Coelioxys sp., Voorheesville, August

Andronicus sp., Center, June

Ceratina dupla Say, Rochester, July 29, 1925

NEW EASTERN SPECIES OF MEDETERUS
(DOLICHOPODIDAE, DIPTERA)

By C. H. CURRAN

(A contribution from the Division of Systematic Entomology,
Entomological Branch, Department of Agriculture, Ottawa, Canada)

The species of *Medeterus* described in the following pages are mostly from the collection of the New York State Museum, Albany. They include some interesting forms, *M. crassivenis* being the first Nearctic species with the third vein widened and flattened. Among the useful characters available for the separation of species are the numbers and strength of the bristles of the mesonotum and the presence or absence of bristles on the femora and length of the hair on these parts.

The biological data in relation to the various species are taken from New York State Museum records kindly placed at our disposal by Dr E. P. Felt, State Entomologist.

***Medeterus crassivenis* n. sp.**

Readily distinguished from Nearctic species by the very much broadened basal third of the fifth longitudinal vein. Differs from *incrassatus* Frey (Europe) in having the last section of the fifth vein hardly half as long as the large cross vein instead of twice as long, and in the color.

Length, 2 mm. *Male*. Face blackish green, black below, thinly greyish pollinose. Front opaque brown pollinose. Back of head brownish grey pollinose, the hairs whitish on lower half, black above. Palpi black. Antennae wholly black; third joint small, a little wider than long, the apical end flattened, but little convex, the arista in the middle, long, slender.

Sides of mesonotum, posterior depression and pleura, greyish white pollinose, the mesonotum elsewhere with brown pollen. Acrostical bristles in two rows, quite short, becoming a little longer posteriorly; anterior dorso-central bristles not as long as the acrosticals; the front two posterior ones long, but much weaker than the two posterior pair: one of the anterior acrosticals is fairly strong, but weaker than the first posterior. A single black bristle above front coxae. Scutellum with four bristles.

Legs black or brownish black, the immediate knees more or less reddish. Front four tarsi brownish yellow, with broad tips of the first two joints and the whole of the remaining joints black. Posterior femora with a row of five or six long hairs anteriorly on the apical half, their antero-ventral surface also with long hairs on apical half. Middle tibiae with a single small antero-dorsal bristle near the base.

Wings greyish hyaline; third vein gently curved, the fourth evenly approaching it, widely separated at costa which the fourth vein reaches before the apex of the wing. Swelling of fifth vein as wide as the width of the second basal cell at the middle.

Abdomen blackish, with green reflections except on the middle line and apex, the whole brownish pollinose, the hairs black. Genitalia blackish, the appendages reddish; large and without apparent peduncle.

Female. Face a little wider, black, grey pollinose; front with greyish brown pollen. Anterior femora with six or seven long hairs on apical fourth or fifth of postero-ventral edge; middle tibiae with antero and postero-dorsal bristle at basal fourth (both these characters perhaps present in male). Wings without enlarged fifth vein. Otherwise as in male.

Holotype: ♂, Nassau, N. Y., May 10, 1911; in New York State Museum, Albany.

Allotype: ♀, Cooperstown, N. Y., August 4, 1911.

Paratypes: 2♂, Cooperstown, August 2, 1911; ♀, August 23, 1911. ♂ and ♀.

Paratypes No. 1323 in Canadian National Collection, Ottawa.

This species was reared from decaying oak bark collected at Nassau, N. Y., November 25, 1910, and infested with the larvae of *Leptosyna quercus* Felt and also yellowish larvae of an undetermined species of *Sciara*.

***Medeterus furcatus* n. sp.**

In Van Duzee's table runs to *erophilus* Wh. (couplet 43, p. 260. There is an error in this couplet; the word "one-half" should be replaced by "twice"). It differs markedly from this species; the posterior cross vein is almost two-thirds as long as last section of fifth vein; tibiae yellow; hind tibiae with comb of abundant yellow hair on inner side.

Length, 2.25 mm. *Male.* Face greenish black, yellowish grey pollinose; front greyish pollinose. Hair of back of head white, black on upper fourth. Palpi shining black. Antennae black;

third joint subtriangular, as long as wide, the arista moderately before the tip.

Pleura, sides and posterior of mesonotum, grey pollinose, the anterior portion with brownish grey pollen. Acrosticals moderately strong; two strong and two weak posterior dorsocentrals, the anterior dorsocentrals increasing in length behind, but not generally distinct from the abundant hairs on the sides in front of the suture, these hairs arranged in six or seven rows. Scutellum with four bristles. Propleural hairs white.

Coxae and femora black, the latter with reddish yellow apices, the former with white hairs and black bristles; hind coxae with single black bristle on outer surface. Tibiae and tarsi reddish yellow, the apical two or three tarsal joints brownish. Legs with white hair; tibiae without bristles; hind femora with three or four hairs in row on the middle of the posterior surface before the apex, the lower posterior edges of the front and hind femora without conspicuously long hairs.

Wings greyish hyaline, third vein slightly curved; fourth vein parallel with third on apical third of last section of fourth vein which ends slightly before the apex of the wing. Squamae yellow, with brownish border and yellow cilia. Halteres yellow.

Abdomen blackish, with some greenish reflections laterally; covered with thin greyish brown pollen; the hairs yellowish. Genitalia black, the appendages reddish brown, the inner (large) lamellae forked on apical half.

Female. Differs only sexually.

Holotype: ♂, Nassau, N. Y., April, 15, 1911, in New York State Museum, Albany.

Allotype: ♀, Nassau, N. Y., April 24, 1911.

Paratype: ♂, Nassau, April 26, 1911; No. 1324 in Canadian National Collection.

The fly was reared under the same conditions as those described above for *M. venatus* and in addition was obtained from chestnut bark infested with *Miastor americana* Felt. Larvae collected October 5, 1910. This latter lot also produced species of *Lestodiplosis*.

***Medeterus venatus* n. sp.**

Traces out to *frontalis* in Van Duzee's key but the thorax is grey pollinose and the acrostical bristles only about half as strong.

Length, 2.25 mm. *Male.* Face greenish black, the upper section very thinly grey pollinose, the front with dense grey pollen. Hair

of back of head brownish yellow, black above. Palpi shining black. Antennae black; third joint a little longer than wide, cordate, the arista a little above the apex.

Thorax grey pollinose, with two or three very obscure brownish vittae, the bright blue green ground color visible in some lights. Four pairs of dorso-centrals, about four hairs in front of each row; acrostical bristles moderately strong. Propleural bristle black; four scutellars.

Legs black; knees reddish; middle basitarsi brownish yellow except the apex. Coxal hairs brownish yellow. Middle femora sparsely short ciliate along antero-ventral edge, none of the hairs longer than half the width of the femur (in frontalis they are almost as long as femoral width); posterior femora with three or four anterior bristles before the end, and with several long ventral hairs apically. Middle tibiae with two bristles. Posterior basitarsus a little more than half as long as second joint.

Wings cinereous hyaline; fourth vein ending in wing tip, evenly approaching the third, the two not parallel; ultimate section of fifth vein about once and one-half as long as the cross vein. Squamae reddish with brownish yellow cilia; halteres reddish.

Abdomen black, with greenish reflections, thinly greyish pollinose; hair brown. Genitalia black; appendages brownish red; outer appendages furcate on apical third, the lower fork slender.

Female. Agrees with male in all respects.

Holotype: ♂, Nassau, N. Y., May 9, 1911; in New York State Museum, Albany.

Allotype: ♀, same data.

Paratypes: 3 ♀, Nassau, April 29, 1911. Two paratypes, No. 1325 in Canadian National Collection.

This species was reared from partly decayed chestnut bark collected at Nassau, N. Y., November 24, 1910. The bark was inhabited by a number of dipterous species. *Winnertzia pectinata* Felt, *Janietella ligni* Felt, *Lonchea polita* Say, *Xylophagus lugens* Lw., *Pseudotephritis vau* Say and a species of *Lestodiplosis* were all reared from this lot as well as the above mentioned *Medeterus*. *Lestodiplosis* is a common predator of gall midge larvae and presumably restricts itself to the smaller, weaker larvae in this lot. *Chrysis verticalis* Patton was also obtained.

***Medeterus simplicipes* n. sp.**

Presuming the hairs above the front coxae to be black, this species runs to *maurus* Wheeler in Van Duzee's key but the posterior

tibiae and tarsi are wholly yellow, the front pollinose, etc. If the propleural bristles are pale it traces to couplet 43, differing from both *modestus* and *xerophilus* in the length of the last section of the fifth vein which is once and one-half as long as the cross vein and it further differs from these in the color of the legs, etc.

Length, 1.75 mm. *Male*. Face black, the upper section with green reflections, thinly greyish pollinose; front grey pollinose. Back of head with white hair, the cilia black. Proboscis black. Antennae dark reddish, third joint black, as long as wide, oblique and gently convex above, arista slightly before the tip.

Thorax brownish grey pollinose; five dorso-centrals, the posterior two strong, the anterior row of small hairs conspicuous; acrosticals of moderate strength; hairs outside the dorso-centrals not in rows, fairly abundant. Scutellum with four bristles.

Coxae and femora black, the latter with yellow apices; tibiae and tarsi yellow, the apices of the front tarsi infuscated. Middle tibiae with anterior and smaller posterior bristle at basal fourth; hind femora with two or three black bristles toward apex in front; hair of legs yellow.

Wings cinereous hyaline; venation as in *furcatus*. Squamae and halteres yellow, the former yellowish ciliate.

Abdomen black, with green reflections, thinly grey pollinose; pale haired. Genitalia black, small, the short appendages reddish.

Holotype: ♂, Nassau, N. Y., April 29, 1911, in New York State Museum, Albany.

This insect was reared under the same conditions and in association with *M. venatus*.

***Medeterus vanduzeei* n. sp.**

In Van Duzee's key traces out to *oregonensis* but the face is bronze green, not blue, halteres reddish, etc. From *maurus* it differs in the pale middle tibiae and the ultimate section of the fifth vein being equally as long as the cross vein.

Length, 3.5 mm. *Male*. Face bronze-green, the sides and sutural fascia ochre-brown pollinose; front black, brown pollinose. Back of head with unusually long yellow hairs, the cilia black above.

Palpi shining black. Antennae red; third joint black, broader than long, notched for the reception of the slender, black arista which is practically bare.

Thorax greyish pollinose, the mesonotum more brownish, indistinctly brownish vittate. Seven dorso-centrals, the three-presutural pair rather short and preceded by three or four short hairs; acrostical

bristles extending to the second posterior dorso-centrals, moderately strong. Bristly hairs outside the dorso-centrals not in rows, fairly numerous. Propleural bristles, three, black. Scutellum with four bristles.

Legs shining black, wholly clothed with black hair, which is fairly conspicuous, no bristles on hind femora; middle tibiae with two small bristles; basal joint of hind tarsi two-thirds as long as second.

Wings hyaline with slight infuscation; venation as in *oregonensis* except for lengths of cross vein and last section of fifth vein. Squamae yellow, with brown border and dark yellow fringe. Halteres reddish, with slight browning.

Abdomen and genitalia deep shining black, with black hair; genital appendages black; much as in *oregonensis* but the hair much shorter.

Holotype: ♂, Aylmer, Que., July 31, 1924 (Curran); No. 1326 in the Canadian National Collection, Ottawa.

BIBLIOGRAPHY

Van Duzee, Millard C.

- 1919 Key to the North American Species of the Dipterous Genus *Medeterus*, with Description of a New Species. Proc. Calif. Acad. Sci., 9: 257-70

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