The Principal Bulb Pests in Michigan
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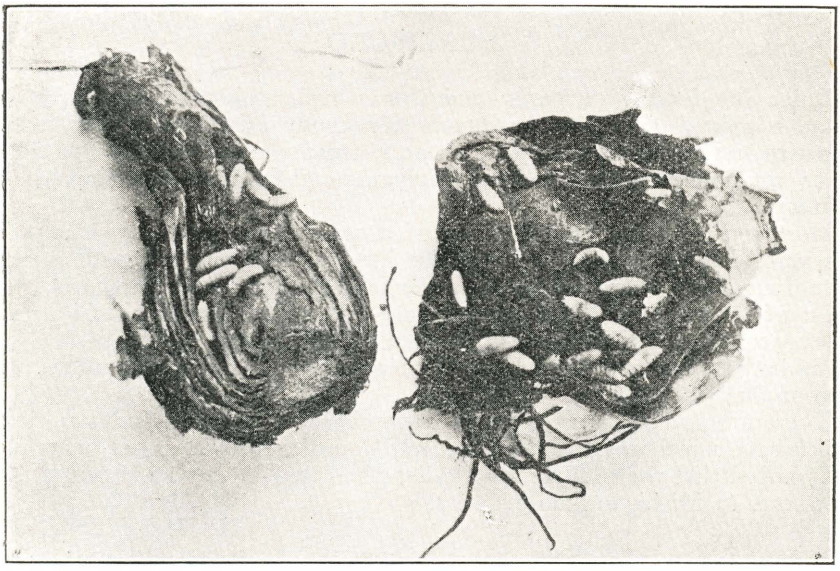

AGRICULTURAL EXPERIMENT STATION

MICHIGAN STATE COLLEGE
Of Agriculture and Applied Science

SECTION OF ENTOMOLOGY

East Lansing, Michigan

FOREWORD

Bulbs for forcing purposes and for ornamental plantings have been popular among European gardeners for centuries. Until very recently, America has imported most of her stock from Europe, mainly because the bulbs could be imported more cheaply than they could be grown in this country.

However, with the establishment of a quarantine regulating importation, the bulb-growing industry of America has received a new impetus. It has been found that there are many areas in America which, from the standpoint of drainage, soil, and moisture are admirably fitted for bulb-growing. In consequence, extensive areas devoted to the growing of bulbs now exist along both coasts, and sections of Illinois, Indiana, Michigan, and Tennessee also produce many bulbs.

There are several insect pests that gravely affect the bulb industry, insects which have somehow managed to get into America in spite of our quarantines. It is hoped that the preliminary studies presented in this bulletin will be of assistance to Michigan bulb growers.

R. H. PETTIT,
Entomologist of Experiment Station.

The Principal Bulb Pests in Michigan

EUGENIA I. McDANIEL

Eumerus strigatus

"The Lesser Bulb-fly" or "Lunate Onion Fly"

The name Lesser bulb-fly is popularly given to two species of bulb-flies, *Eumerus strigatus* Flyn., and *E. tuberculatus* Rond., which are so closely related that it is impossible to distinguish one from the other except by a careful examination of the internal organs of the males,* their life-histories, habits, and general external appearance being apparently identical.

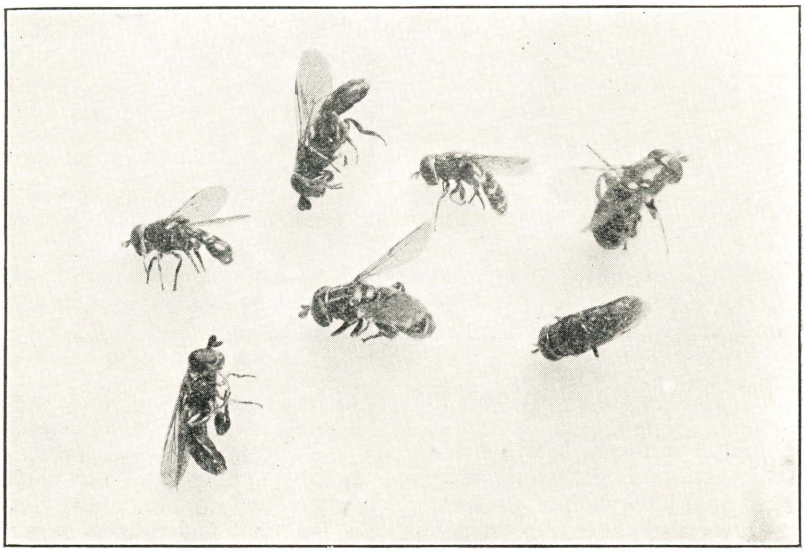

Fig. 1.—Adult Flies of Lesser Bulb-fly, enlarged.

Eumerus strigatus has been reared from bulbs grown in Michigan. According to written accounts, it is the predominating species in America, though it is probable that we have both species to contend with. In Europe, the two species are reported as equally abundant and are often found working side by side even in the same bulb.

Narcissus bulbs seem to be the preferred food, especially where the bulbs

*Collins, J. E.—Ent. Mo. Mag., Vol. LVI., pp. 102-106, 1920.

have been injured or are diseased. Besides the narcissus, the lesser bulb-fly attacks hyacinth, onions, potatoes, parsnips, and Iris roots. When Iris roots are attacked by the Iris borer, *Marconoctua onusta,* a putrefaction or breaking down of the tissues takes place, which makes the injured plant especially attractive to the females of the lesser bulb-fly for the deposition of eggs. In Europe, this insect has been known to destroy whole crops of onions, and to attack both potatoes and parsnips. In America, the species has been recognized for a number of years as a potential enemy of the common onion, an enemy of no mean importance.

Description

The adult of the lesser bulb-fly is about the size of the common house fly, and, when at rest, the wings are folded flat on the back, giving it a wasp-like appearance. It belongs to the family Syrphidae and like other Syrphids it is abroad and active on bright, warm days. At such times, it hovers in mid-air over its food supply or over the bulb field, while on cold damp,

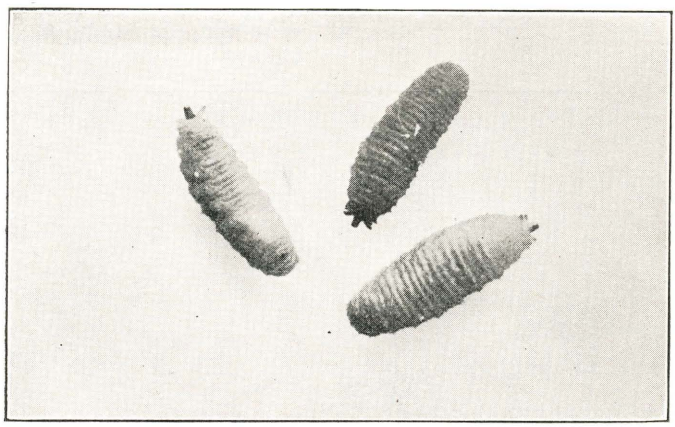

Fig. 2.—Larvae of Lesser Bulb-fly, enlarged.

cloudy days it is rarely in evidence. The fly is robust, black in color, with a metallic bronze luster when observed in the sunlight, and the abdomen is marked with three white, cresentric, plumose bands. The adults live for two or three weeks, feeding on pollen. In the field, individuals have been taken on flowers of various Compositae and Umbelliferae, while caged specimens are capable of completing their existence on sugar sirup or on honey and water.

Life History

There are two broods a year in this latitude and usually a partial third brood. Winter is passed in the larval stage, mature individuals pupating early in the spring, shortly after which the adults of the first generation appear. In Michigan, pupation takes place about the time the frost is out of the ground, the first adults appearing sometime in the latter part of May, or, in late seasons, in early June. During the summer, about six

weeks time is required to produce a generation, therefore the second brood appears in late July or early August, and the third generation is in evidence in September. Unfortunately, the broods are not well defined but adults keep straggling along throughout the summer. There are periods however when adults are present in much greater numbers than at others.

The species has developed a thrifty means of protecting itself from extinction. Adults appear from the overwintering larvae and lay eggs which are to produce the next generation. It has been observed that larvae from these eggs do not all mature together, even when enjoying the same food supply, moisture, and temperature conditions; but that some individuals remain in the larval state until the following spring, thus reducing the hazard of extinction should weather conditions prove unfavorable or should natural enemies appear.

Egg-laying begins when the adults are five or six days old. Each female probably places, singly or in clumps, approximately a hundred eggs in a lifetime. The eggs hatch into tiny, colorless, active larvae in from three to four days.

The larvae grow rapidly, reaching maturity in about a month. Each greyish-white mature larva is sub-cylindrical in form, the posterior end being ornamented by a conspicuous reddish-brown tubercle. They thrive best in warm, moist quarters and many larvae may occupy the same bulb. It is not unusual to find a hundred or so larvae in a single bulb. Of course, where the infestation is heavy, the life of the bulb is doomed, and its interior rots down to a putrid mass in which the larvae rest with their posterior spiracles protruding upward to the surface for air.

The pupae prefer dry conditions. For this reason, the larvae of the later summer broods migrate from the rotting tissue in which they have developed, and pupate upon the neck of a bulb or on the foliage itself. The early spring generation, however, is forced to accept somewhat less attractive conditions. There is no foliage at this time and the soil is filled in about the necks of the bulbs. The larvae of this generation frequently pupate in the soil quite close to the surface, and, at times, at a distance from the infested bulb. The pupal stage lasts for about two weeks.

Injury

When growing bulbs are infested with the lesser bulb-fly, the growth is dwarfed and the leaves turn yellow. Also, the foliage of infested bulbs dies earlier than that of healthy bulbs.

When heavily infested, the detection of worthless bulbs is easily accomplished, for the presence of a hundred or so larvae, each measuring over a quarter of an inch in length, in an ordinary bulb, leaves no room for doubt. Such bulbs are completely destroyed, the whole center being broken down. Where the infestation is limited to one or even to half a dozen larvae, their presence is harder to detect without destroying the bulb. Such bulbs, however, have a "give" when pressed between the thumb and finger, which can be detected after some practice.

When onions are attacked, the top dies down almost immediately, even where only a few larvae are present, though it is a well known fact that the onion will harbor a number of common onion maggots and still survive.

The type of injury to the bulb is governed somewhat by the season. If the foliage is still attached to the bulb, the eggs may be placed on it, the young larvae finding their ways down to the bulb soon after hatching; or,

when the top has dried off and blown away, the winged female may crawl down the opening and place her eggs on the neck of the exposed bulb. The larvae from these eggs crawl down between the bulb scales entering the bulb from the top. Later in the season or after the cavity in the soil around the bulb neck has been filled in, the eggs are laid either on the surface of the ground adjacent to the bulb or the fly may crawl down and place her eggs on the side of the bulb itself. The larvae from these eggs usually migrate downward and collect about the base at the roots.

The young larvae seem to have little or no trouble in establishing themselves on bulbs, even healthy ones, provided they can reach them before they, the larvae, become too mature. The larvae do not migrate from one bulb to another but when the food supply is insufficient, development is retarded and the larvae either perish or develop into undersized flies which delay their appearance until somewhat later than their better fed relatives.

Experiments have proved that it is practically impossible for the newly hatched larva to penetrate the soil in search of food,* a layer of soil an

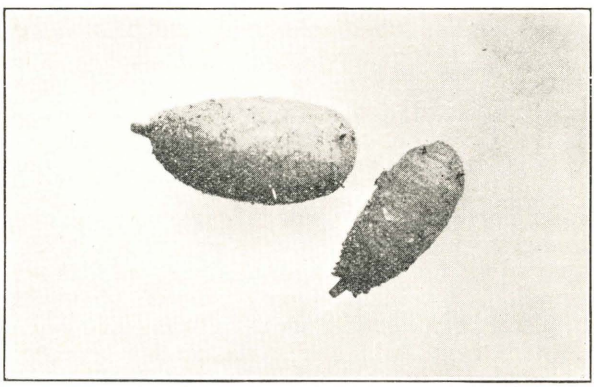

Fig. 3.—Pupae of Lesser Bulb-fly, enlarged.

inch deep being sufficient to give protection, except in cases where bits of withered stalks appear on the surface of the soil.

The females oviposit freely on healthy bulbs, but, in the presence of nematode infested bulbs, they show a marked preference for the latter.

The lesser bulb-fly is always attracted to a weakened bulb, whether the original cause of the trouble be due to nematodes, mites, or disease, and it is certain that many injured bulbs so attacked would recover and produce flowers, if they were able to escape the ravages of the fly.

Two outstanding papers on the lesser bulb-fly have been published. The investigators were fortunate in being able to work in an infested region and could carry on their research unhampered by the fear of spreading the infestation.

Hodson, W. E. H.—Bionomics of the Lesser Bulb-flies, *Eumerus strigatus* Flyn., and *Eumerus tuberculatus* Rond., in Southwest England.
Bul. of Ent. Res., Vol. XVII,Pt. 4, pp. 373-383, 1927.

*Hodson, W. E. H.—Bul. Ent. Res., Vol. XVII, Pt. 4, p. 379, 1927.

Wilcox, Joseph—The Lesser Bulb-fly, *Eumerus strigatus* Fallen, in Oregon.
Jour. Econ. Ent., Vol. XIX, No. 5, pp. 762-772, 1926.

Control

It is well known to entomologists, that certain seasons are typical maggot years. When the spring opens with cold, wet weather and when growth is consequently delayed, conditions are ideal for maggots.

It is unreasonable to expect any one method to give 100 per cent control. The successful grower will be obliged to use all artificial means at his command, which are hot water treatment, fumigation, mercuric chloride treatment, and destruction of soft bulbs with any and all preventive measures known or yet to be developed.

Corrosive Sublimate Treatment

Corrosive sublimate has been recognized for a number of years as a very effective agent for the control of a number of root-maggots. Applications should start about the time the flies begin to deposit eggs, and it will be necessary to repeat the application from time to time. Corrosive sublimate is a *violent poison* and should be handled only by reliable individuals who thoroughly understand what they are doing. When in solution, it has the property of combining with metals very quickly, not only ruining the metal but breaking down the solution as well. Therefore it is imperative that the solution be stored in wooden, earthen, or glass containers and that precautions be taken to prevent it from coming in contact with metal at any time. Metal buckets, dippers, or sprinkling pots should be coated, wherever they come in contact with the liquid, with wax, asphaltum, or some similar waterproof material.

Care should be taken to make the application in such a way that the liquid does not get on the foliage, since burning is almost sure to follow. A sprinkling pot, with the "rose" removed, and the spout partly plugged, makes as convenient an implement for applying the solution as anything.

All vessels containing the solution must be covered to prevent livestock, cats, dogs, or poultry from drinking it. Care must be taken by the operator not to get any of the liquid on the hands or clothing, since some individuals are very susceptible to mercury poisoning and this particular salt of mercury is easily absorbed.

The solution may be prepared as follows: Dissolve one ounce of corrosive sublimate in eight gallons of water, using a wooden or earthen container. The crystals may be dissolved in a small amount of hot water and stirred into the full amount of water. No solution stronger than one ounce to eight gallons should be used, and very favorable results have followed the use of one ounce to 10 gallons of water. The liquid is simply poured on the soil about the plant, using about one-half teacupful to a plant.

Fumigation

These bulb-flies may be readily destroyed by fumigation. If infested bulbs are placed in a closed container with a few drops of chloroform, the larvae will come to the surface. Two fumigating agents have been tried out with success, and it is altogether probable that other fumigants would be of equal value. The two fumigants advocated by the United States

Federal Horticultural board as promulgated in Quarantine No. 62, are carbon disulphide and paradichlorobenzene. The following discussion of the carbon disulphide treatment is taken from the United States Federal Horticultural Board Quarantine No. 62.

"Experimental work conducted in California indicates that the vacuum method of fumigation with carbon disulphide is effective against the bulb flies. In the event, therefore, that inspection reveals that the bulbs are infested with bulb-flies only, the grower may have the optional treatment of vacuum fumigation. This treatment should not be given until the bulbs have been thoroughly cured and freed from all dirt and debris. Previous to the introduction of carbon disulphide into the fumigation tank, a 27-inch mercurial vacuum should be produced. The dosage shall be not less than 2½ pounds nor more than 3 pounds per 100 cubic feet of space. The period of exposure shall be not less than one and three-fourths hours nor more than two hours, computed from the time the indicator on the vacuum gauge reaches zero. Bulbs when removed from the fumigator should be thoroughly aired and should not be immediately brought into the direct sun rays or wind. Bulbs should not be fumigated when the atmospheric temperature is below 60 degrees F. The optimum temperature conditions are between 70 and 80 degrees, with a limit of 10 degrees either way as a tolerance."

Paradichlorobenzene fumigation has given some promising results.* When used at the rate of four ounces per cubic foot for a period of 120 hours, all larvae were killed and the bulbs were apparently unharmed, as evidenced both at the end of the fumigation and after the bulbs had been planted and grown. The crystals were spread over the bottom of the fumigation box and covered with burlaps to prevent the crystals from coming in contact with the bulbs themselves. The bulbs were placed on trays and were in layers about four inches deep.

Hot Water Treatment

The United States Federal Horticultural Board Quarantine No. 62, gives the following directions for carrying out the hot water treatment:

"This treatment involves the submersion of the bulbs in wire baskets, slat boxes, or other containers, in water ranging in temperature from 110 to 111.5 degrees F. The period of submersion shall be for not less than three hours, computed from the time the water regains the loss of temperature occasioned when the bulbs are submerged. The range of temperature during this period shall not fall below 110 degrees and for the safety of the bulbs should not exceed 111.5 degrees F. In order that all bulbs may be exposed to a constant and uniformly distributed temperature, the water should be agitated or circulated during the period of treatment. To prevent heating of the bulbs following the treatment, it is believed desirable that they be plunged into or syringed with cold water promptly on removal from the sterilizer. Bulbs which are not intended for immediate planting should be dried by some means, mechanical or otherwise, before storage or shipment." In case fungus or other diseases are present, the hot water treatment may incidentally result in spreading infection. Growers, therefore, sometimes resort to the expedient of immediately following the hot water treatment by a bath containing a disinfectant.

The hot water treatment is the only treatment known at the present time that will control the bulb nematode *Tylenchus dipsaci* Kuhn. For this rea-

*Hodson, W. E. H.—Bul. Ent. Res., Vol. XVII, Pt. 4, p. 382, 1927.

son, it is usually considered the standard remedy by growers. It has been used by European bulb fanciers for generations. Nevertheless, even now the treatment presents its own difficulties and involves a number of problems.

Bulbs recently dug do not stand the hot water treatment as well as bulbs that have been above ground long enough to become dry.

Nematodes are less resistant to the hot water treatment immediately after the bulbs are removed from the ground than if the treatment is deferred, for if the bulbs are permitted to dry, the nematodes on the outside of the bulb go into an encysted or resting stage and are resistant to water at the temperature recommended.

Growers are constantly complaining that bulbs subjected to this treatment either fail to bloom if forced during the winter or else put up straggly blossoms the following season. Experiments* carried out by the United States government in California indicate that the time of treatment as well as the temperature of the water has considerable to do with the injury caused by the hot water treatment. Bulbs treated in July with water at 110 degrees F. for a period of three hours, developed normally and produced marketable flowers. Practically the same result was obtained when water at 114 degrees F. was used. The experiment shows that the later in the season the treatment was applied, the less satisfactory were the results.

Field Practices

Aside from the control measures just discussed, there are certain field practices which if followed out will do much to lessen the damage caused by the fly.

Where the soil has been packed around the neck of the bulb so that no opening is left around the withered foliage, the percentage of infestation will not be so high.

The narcissus plant, after its blooming period is over, normally dries down, the top shriveling and eventually blowing away. Where the shriveled top breaks away from the bulb, there remains a hole from the soil surface down to the bulb. Through this passage the larvae often gain entrance to the bulb.

It is entirely practical to rake off all debris, just before the active period of egg laying, and while so doing to fill up these holes, thus making it more difficult for the young larvae to reach the bulbs.

Varieties which do not dry up and shrivel in time to apply the foregoing treatment, can be worked over with a hoe so that the yellowing leaves are cut off an inch or so above the surface and the soil pulled over so that the stubs are buried. Plants which are still vigorous and have not commenced to go to pieces, do not seem to be subject to attack. Therefore, varieties which at the time of egg laying are in good vigor, may perhaps advantageously be left alone.†

The flies find newly dug bulbs very attractive for egg laying, and, when they are present in numbers at digging time, many eggs are naturally deposited on the fresh bulbs. It is a common complaint among growers that severe losses from the fly are most common the year after transplanting.

Where possible, it would be best to select a season when the flies were not abundant. In other words, do not start a new bulb field when the maggot is especially troublesome.

*Doucette, Chas. F.—Mo. Bul. Dept. Agr. Cal., Vol. XVI, No. 4, pp. 236-238, 1927.
†Hodson, W. E. H.—Bul. Ent. Res., Vol. XVII, Pt. 4, p. 383, 1927.

Discarding Soft Bulbs

All bulbs which come under suspicion, should be examined and, if found infested, should either be buried in a deep pit or destroyed by fire. If they are left exposed above ground, enough moisture may remain in the bulb for the larvae to produce adult flies.

Decoy Bulbs

When the flies are present at digging time, rejected or diseased bulbs are sometimes piled about the field in exposed places. The females find such heaps ideal places for egg-laying. Care must be taken to remove and destroy these heaps frequently since only six weeks is required to produce a generation of flies during midsummer.

Curing Bulbs

Bulbs cured in the open and protected from the sunlight, as in open sheds, are not attacked by the flies. Such conditions give the bulbs ample opportunity to cure and produce as good if not better plants than those dried in the direct sunshine.

Crop Rotation

Crop rotation is in many ways impracticable, since bulbs are grown for years on the same fields. Yet, where one or any of these bulb pests become too numerous, crop rotation many times relieves the situation. This is especially true where the soil becomes loaded down with nematodes. A field infested with the bulb nematodes can be cleared of them by keeping some crop other than bulbs in the field for three years, for, while the nematode is recorded from a large number of hosts, it seems to develop races and each race ordinarily dies out before it is capable of re-establishing itself in a new host.

Clean Culture

All bulbs should be removed from the soil at digging time, and, since the onion is such an ideal alternate food-plant, onions in the vicinity should be watched and cultivated with considerable care. Abandoned onion fields of any description offer ideal breeding quarters for the lesser bulb-fly. Onions attacked by the onion maggot, *Hylemyia antiqua,* are of course especially susceptible to attack just as are diseased or nematode infested narcissus bulbs.

Merodon equestris Fab.

The Larger Bulb-fly

The larger bulb-fly, *Merodon equestris* is an European species which has already been the cause of extensive injury in American bulb fields. The most severe losses have occurred in the bulb-growing region of the Pacific coast.

Fig. 4.—Adult and Pupa-case of Larger Bulb-fly, slightly enlarged, from E. O. Essig, University of California.

It is rather surprising that the spread of this major bulb pest, which is widely distributed throughout the old world, has been so successfully checked by quarantine measures, since its larvae are very well concealed in dried bulbs and consequently difficult to detect. The larger bulb-fly is believed to be a native of southern Europe. It feeds on a variety of bulbs of which the narcissus seems to be first choice. It has been reported from narcissus, lily, amaryllis, Vollota, Habranthus, Eucycles, Saltonia, Scilla nutoris, and onions.

Description

The larger bulb-fly belongs to the family Syrphidae. The adults are about the size of the common honeybee, while their general appearance and be-

havior is suggestive of some of the smaller bumble-bees. There is considerable variation in coloration and in the markings of individuals of the same brood. Some individuals are pale, amber yellow while others are black or dark metallic green, and color gradations are found between these two extremes. The emergence of adults from their pupa-cases as well as the laying of the eggs usually takes place in the forenoon.

The larger bulb-fly is inactive on cloudy days, late in the afternoon, and during dark, damp, cold weather. On warm bright days, however, the adults may be seen hovering over the bulb fields or congregating on some food plant. They usually live for three or four weeks and are known to feed on pollen. Many individuals have been taken feeding on rose.* In the confinement of breeding cages, the adults do very nicely on sugar and water or on honey and water.

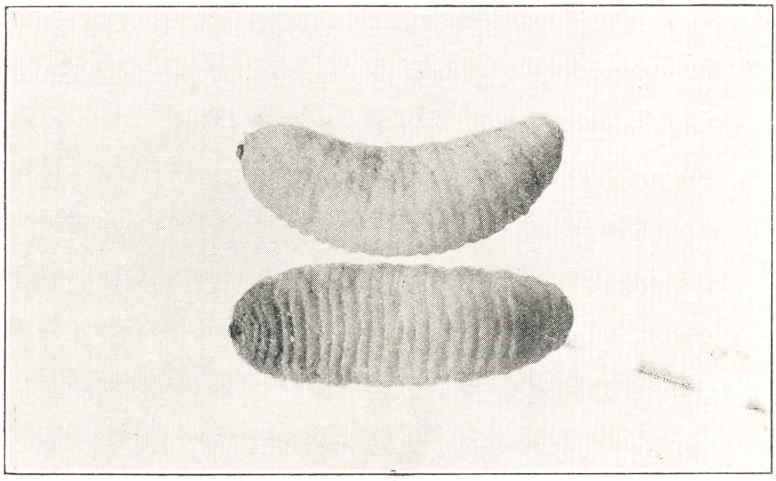

Fig. 5.—Larvae of Larger Bulb-fly, enlarged, from E. O. Essig, University of California.

The larva of the larger bulb-fly is a dirty-white or greyish-brown grub which measures from one-half to three-fourths of an inch in length, its general shape and appearance resembling that of some of the bot-flies. The body is distinctly segmented, with the dorsal surface arched and the ventral surface flattened. The head is ill defined, and is provided with two black chitinous hooks, and two spiracular openings. There are two spiracular openings at the posterior end as well.

Life History

There is but one annual generation. The first adult appears in May or June, and adults continue to emerge from then on throughout the summer. The females deposit some of their eggs at the bases of the leaves, some on bud scales, but the largest number are placed in the ground itself. These eggs hatch in from a week to 10 days. The young larvae enter the bulb,

*Broadbent, B. M.—Jr. Econ. Ent., Vol. XX, No. 1, p. 102, 1927.

where they feed for a period of about 10 months. Sometimes a larva will desert the bulb on which it has been feeding but this is not the rule. While very many eggs are laid on a single bulb, it is rare to find more than one larva to a bulb, occasionally there may be two, and, at times, even three in a large bulb but such an occurrence is rare. The larvae which have hatched in May or June are apparently full-grown before fall, but they remain in the larval stage over winter, pupation taking place in the spring. The pupal period lasts for five or six weeks. When a larva is ready to pupate, it works up to the surface, usually directly over its tunnel in the bulb itself and there,

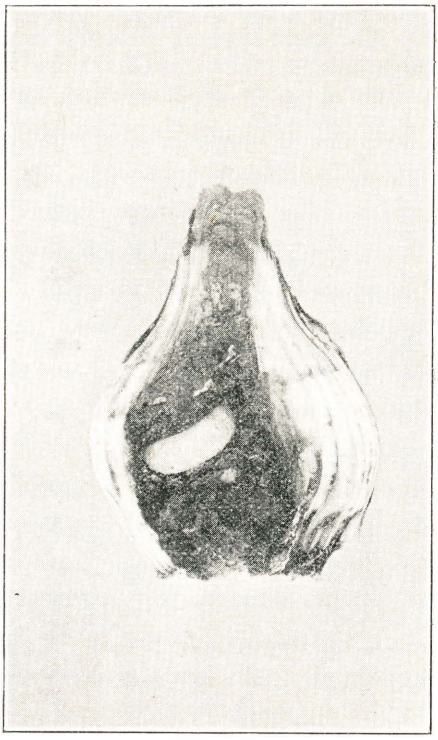

Fig. 6.—Larva of Larger Bulb-fly, in bulb, from E. O. Essig, University of California.

with its anterior spiracles exposed, it pupates. The greenish brown pupa is quite similar to the larva in appearance, the segmentation remaining distinct. Adult flies continue to emerge over an extended period, and consequently larvae in all stages of development are always to be found in fields where the infestation is severe.

Injury

The young larva usually enters the bulb through the base, working its way up into the bulb itself where it hollows out the center, at times leaving only the outer shell. The injured portion turns black and decay often follows.

In the case of very small bulbs, however, the destruction is seldom complete, in fact, the infested bulb may continue its development and produce flowers but its vitality is usually so impaired that it does not produce healthy bulbs. It is difficult to detect infested bulbs after they are dug because they are quite firm when tested by pressure between thumb and fingers. The basal plates of infested bulbs are usually shrunken and corky; a little scraping with a knife will usually disclose the larva, if present.

Control

This species responds to the control measures recommended for the lesser bulb-fly; namely, the hot water treatment (page 8) or the carbon disulphide fumigation (page 8). The bichloride of mercury treatment (page 7) or general field practices (page 9). There seems to be no question but that this species is able to attack healthy bulbs and that bulbs infested by it are very attractive to the lesser bulb-fly.

Rhizoglyphus hyacinthi

The Bulb Mite

There are several species of mites known to infest bulbs. Of these, *Rhizoglyphus hyacinthi* is the one species that has been observed attacking healthy bulbs. This mite seems to be quite universally distributed since it has been reported from practically every state in the Union and is constantly being intercepted in bulb shipments from both Europe and the Orient. It attacks narcissus, hyacinth, tulip, crocus, amaryllis, lily bulbs, dahlia

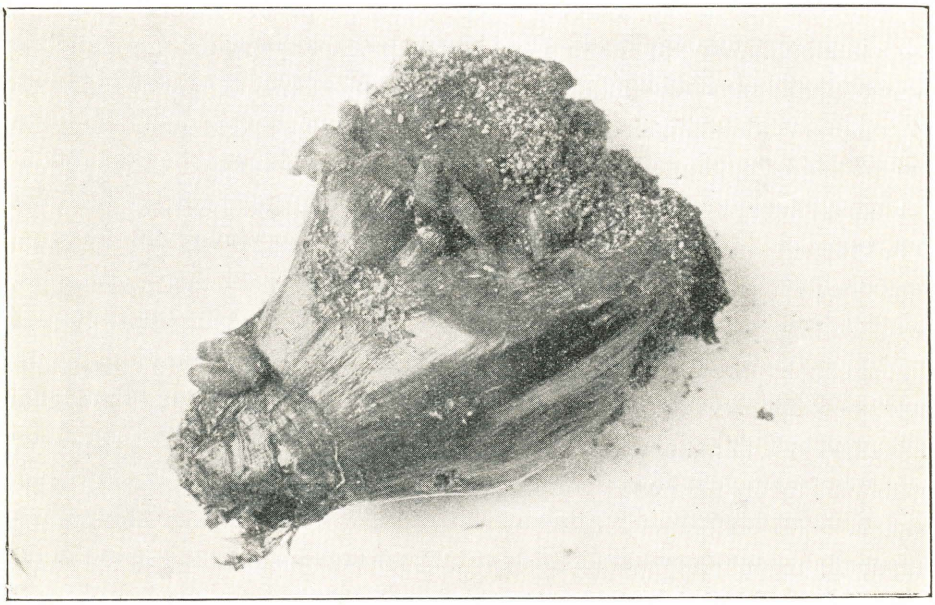

Fig. 7.—Narcissus bulb infested by Bulb-mite, somewhat enlarged. Larvae of Lesser Bulb-fly also present.

roots, orchids, and onions. Narcissus and lily bulbs suffer more from the attacks of mites than other bulbs because their scales are rather loose and afford easy entry for the mite; onions and hyacinths, being more compact, are not attacked so freely; while the bulbs of healthy tulips are seldom severely infested.

Description

The adults are small, almost microscopic in fact. They are yellowish-white tinged with pink or are nearly transparent, with the legs and mouth-parts reddish-brown. Their appearance varies with the stage of their development, both sexes being similar in form. Mature individuals are equipped with four pairs of legs and are capable of moving about freely.

Life History

The adult female places her eggs singly on the scales of the bulbs. It is possible for a single female to place from 50 to 100 eggs in a lifetime. The mites are most active when the humidity is high and when the temperature is between 60 and 80 degrees F., when the temperature drops to 55 degrees F. or lower, they become torpid. In mid-summer or under glass, it is possible for a generation to develop in 30 days. The females live for a month or more, while the males mostly disappear in a week or 10 days. Each egg hatches within a period of from 24 hours to a week. The minute six-legged larval form immediately begins boring into the plant, where it feeds from one to three days before going into an inactive or quiescent stage which lasts about two days.

The nymphs which emerge from this first quiescent stage are eight-legged creatures which feed for two days before entering a second quiescent period

Fig. 8.—Greatly enlarged portion of bulb with Mites shown in Figure 7.

of two days, after which they again molt. No radical change takes place at the time of this molt. The mites then feed for from one to four days before entering a third quiescent stage which lasts for a day or two and from which adults appear.

However, not all individuals develop according to the plan above outlined, part of them develop a stage known as the "hypopus" stage after the second molt. In this stage, the creature becomes a small brown mite quite resistant to unfavorable conditions, very active, and ever on the alert to attach itself to any moving object. The length of time spent in the hypopus stage depends of course on the weather and on the food supply. Several weeks may elapse before the hypopus transforms into the nymph which finally produces an adult. This small, brown hypopus stage is very interesting, without this active resistant stage the species would certainly become extinct. Whenever moisture, temperature, or food conditions become unfavorable for any cause, this stage seems to suddenly appear.

There are many different forms of insect life, which are attracted to rotting bulbs, and in the hypopus stage the mite is capable of attaching itself to such visiting insects and in this way is transported from one place to another.

Injury

Rhizoglyphus hyacinthi prefers solid, healthy bulbs in preference to wet, decaying bulbs. When the bulbs reach an advanced stage of deterioration, the mites migrate, seeking firm bulbs. This is noticeable where bulbs are kept in warm storage quarters.

Mite infested bulbs may be detected by the characteristic brown spots which appear on the surface. Also, infested bulbs become soft and "give" when pressed between the thumb and finger.

The mites work down into the bulb where they increase rapidly in numbers. They feed by scraping the surface of the scales. This injury forms a lesion which is ideal for the development of fungi or bacteria or of bulb-flies, millipeds, or nematodes. It is an accepted fact that otherwise healthy bulbs which are infested by this species are subject to rot. As the disease develops and the bulb becomes soft, the hypopus stage of the mite appears, and migration to healthy bulbs takes place by means of some of its well-known carriers. These healthy bulbs in turn soon become soft and rot.

These mites often enter bulbs before they are removed from the soil with the result that infested bulbs transported or stored under conditions favorable to the mite deteriorate rapidly. This accounts for severe losses which have been suffered by importers of foreign bulbs in the past when shipments have for some reason been delayed or have been unduly long in making their ocean voyage.

Bulbs transported or stored under conditions such as render the mites torpid are solid and no injury develops until the bulbs are placed in the ground, after which the mites become active and the growth of the plants is checked. The leaves of plants infested in this manner turn yellow and the plant fails to flower. This type of injury is noticed more frequently when infested bulbs are used for forcing than when they are grown in the open under favorable conditions.

The hypopus stage of the mite is accused, probably justly, of carrying the various organisms causing rot. The insects which breed in rotting bulbs serve as ready carriers for the mite in this stage, for, where mites are present, the disease spreads unbelievably fast. The potentialities of this species as a pest of the common onion has been illustrated recently in a Michigan onion field. It is hoped that it will be some time before it becomes an established onion pest, since the field above mentioned was completely destroyed.

There are several other species of mites which infest bulbs besides *Rhizoglyphus hyacinthi.* Of these, *Histiostoma rostro-serratus* perhaps occurs the most frequently. It usually occurs in wet, rotten bulbs, and is smaller than the bulb mite. The adults are lighter in color than *hyacinthi* and their abdomens are more pointed. The hypopus stage seems to be quite abundantly produced in this species, in fact, it seems always to be present. Besides the above mentioned species, there are certain predaceous mites belonging to the Laelaptini group which usually are to be found among rotting bulbs, since, in such places, there is always an abundance of food. The mites of this group are brown in color and slightly larger than the bulb-mite.

Control

There seem to be no known remedial measures which really pay for the effort expended in carrying them out. The corrosive sublimate treatment so successful against maggots, seems to have little or no effect on them. Where hot water treatment is employed, such a high temperature has to be maintained to do good work that the bulbs are usually so weakened that they become worthless, and fumigations are not effective.

Some benefit is claimed when bulbs are dipped in 40 per cent nicotine sulphate, diluted in the proportion of one part in 400 parts of water. Where this bath is heated to 122 degrees F. and the bulbs are left in it for 10 minutes, most of the mites are killed. It is a question which the grower must settle for himself whether heat be used along with the nicotine, for while it is fairly effective in eliminating the mites, it often follows that bulbs so treated fail to flower, especially where used for forcing. In the control of this bulb pest, as in the cases of all other pests, certain field practices systematically followed, will do much to solve the problem.

Grow bulbs on well-prepared, carefully-drained soil.

Be careful to plant only sound, healthy bulbs; any bulbs with a "give" when squeezed between the thumb and fingers should be under suspicion.

Burn all soft or rotten bulbs at once; do not let them accumulate because they constitute a serious menace.

Visit the field from time to time and examine any sickly plant. If it is found to be infested, see that it is destroyed at once.

Bulbs should be stored at a temperature which is unfavorable to the development of the mites. Where the storage is kept at approximately 35 degrees F., their development will be checked.

Tylenchus dipsaci Kuhn

The Bulb Nematode

The bulb nematode or "eelworm" is likely to be present wherever bulbs are cultivated, and growers continually risk introducing the pest when they import new bulbs or when they bring in bulbs from different parts of the country. It is one of the true worms and belongs to the roundworms or nematodes. The adult female usually measures about one-twentieth of an inch in length and each female during her lifetime is capable of depositing about two hundred eggs in almost any part of the plant.

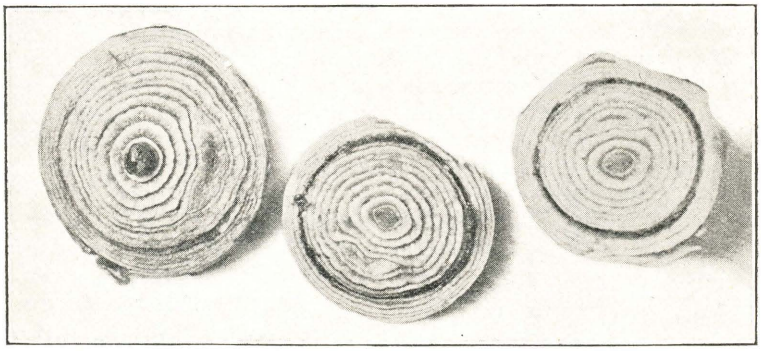

Fig. 9.—Sliced narcissus bulbs showing characteristic ring of dead scales, caused by the bulb nematode.

The young hatch out and enter the plant through some tender, succulent area where they grow to maturity within the plant tissue. Their presence stimulates parts of the plant to increased growth and abnormal swellings develop, which are known among florists of the Old World as "spikkels."

"Spikkels"* may be distinguished from various other abnormalities to which the foliage of bulbs is subject, by drawing the suspected leaves between the fingers. The swellings caused by nematodes feel like lumps, which are really a part of the deep tissue of the leaves or stems, and never surface growths alone. The lumps caused by nematodes can be felt distinctly from both surfaces.

As the plants mature and the nematodes increase in size, the tissue over the swelling or "spikkel" cracks open and turns brown while the area immediately surrounding it turns to a sickly yellow. Where the "spikkels" are abundant on the foliage, the leaves become distorted, have twisted irregular margins, and are paler than the normal foliage.

Where the bulb nematode is present, its effects are most pronounced just at the end of the blooming period. Severely infested plants either fail to put out any foliage at all, or the growth is dwarfed and stunted. Where

*Scott, C. E.—Phytopathology, Vol. 14, 1924.

"spikkels" are numerous on the growth, the foliage shows a tendency to mat down shortly after flowering, which takes place considerably earlier than in the case of healthy bulbs.

The nematodes invade the bulbs themselves from the diseased foliage. Where the infestation on the leaf has been severe, the corresponding bulb scales will be killed. Scales infested in this manner turn brown and if examined early in the season the injured scale appears as a thin layer of dead tissue. When bulbs infested with nematodes are planted, some of the worms desert the bulbs and attack the young growth just as it pushes its way through the soil, while other individuals migrate out into the soil for a foot or more in search of other bulbs.

In Europe, most of the bulbs are said to be grown in beds and cultivated by hand. In America, most of the bulbs are planted in rows and cultivated by machine. The unfortunate part of it all is that the American form of bulb culture is most conducive to nematode dissemination for, where a single infested bulb is present, nematodes from it are carried up and down the rows by the cultivators.

After all bulbs have been removed, nematodes remain in the soil for a considerable period of time. About three years is considered the necessary period of time to starve nematodes out of the soil. The bulb nematode develops a number of strains all belonging to the same species, and each strain shows a very strong tendency to confine itself to one sort of bulb. While this species attacks a number of other hosts, the strain usually perishes before it can adapt itself to its new host.

About three years is required by this nematode to kill a field of bulbs after the infestation has once become established; during the first season of heavy infestation, the foliage shows numerous spikkels; during the second year, the plants become dwarfed or stunted, the leaves and stems being thickened; and during the third year, the bulb produces roots but the foliage usually fails to develop.

The natural migration of nematodes through the soil, becomes apparent when infested bulbs are grown on clean land. A field which has been planted for several years, may present dead patches, around which grow stunted plants. In the next ring, the plants will show many "spikkels" on the leaves and the foliage will die down early, while the bulbs on the outside may possess normal foliage or very few spikkels.

Besides the normal migration, through the soil, and the spread occasioned by washing due to heavy rains, nematodes are distributed by cultivation. Fields should be inspected while the plants are growing, preferably after flowering, and wherever only a few infested plants are found to be present, these should be carefully rogued out. Where the infestation is general, this treatment will not handle the situation. Bulbs which still have a commercial value, should be subjected to the hot water treatment and when replanted should be set out in ground free from nematodes.

There are indications which lead one to believe that too much water in the soil has much to do with the development of nematodes. Bulbs grown on well drained land are seldom attacked.

Marconoctua onusta Grote

The Iris Borer

The iris plant has long been a favorite with the American landscape gardener. The organization of the American Iris Society, has naturally increased the number of these plants used in plantings by developing and bringing out many noble varieties. With such a background it is not at all remarkable that insects which feed on iris should become more abundant each year. The iris-borer, which is the larva of a moth, attacks both wild and cultivated varieties, the infestation seeming to be more severe where the plants are grown on poorly drained soil or in a shaded spot in protected gardens.

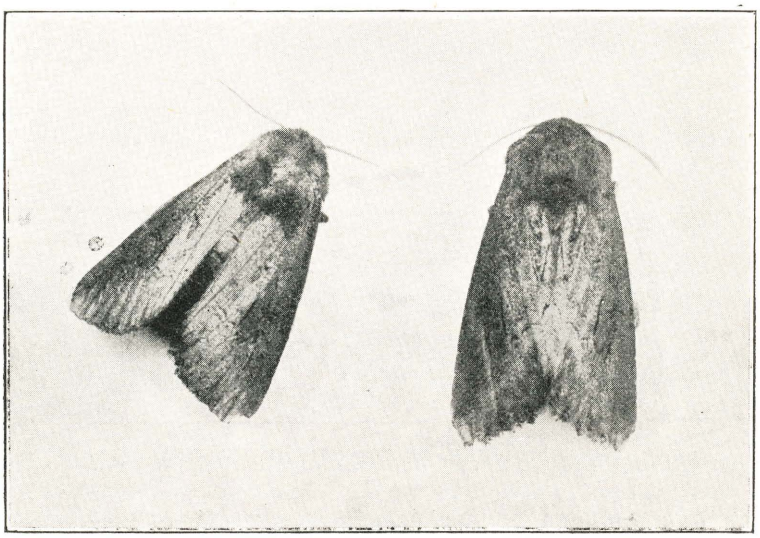

Fig. 10.—Adult moths of Iris-borer, slightly enlarged.

The adult is a large, awkward reddish-brown moth belonging to the family of owlet moths (Noctuidae). The thorax is ornamented with a large triangular tuft of hair-like scales which project forward over the head and the uniformly reddish-brown fore-wings are ornamented on the front third by a bar of black, relieved by a lighter shade. The moths are shy creatures, seldom seen by the grower, since they are active only at night.

The mature larvae are robust, measuring at least two inches in length. They are uniform in color marked along the sides by conspicuous black dots. The color varies considerably, some individuals being a drab or cream color, while others are pink or even lavender.

Life History

There is but one generation each year. The adults appear in September or October and the females place their eggs near the ground on the foliage of the iris plant, although these eggs do not hatch until the following spring. Some time early in June the tiny larvae hatch out and make their ways down into the roots of the plant, where they tunnel into the rhizome. They grow rapidly, from eight to ten weeks being required for them to attain full size. Just before pupation, the larvae become sluggish, quietly resting in their tunnels, often for days. The pupal stage usually lasts only two or three weeks. The adults do not live for any extended period, at least in confinement; the lives of those in our cages enduring from ten to twenty-four hours.

Fig. 11.—Larvae of Iris-borer in Iris root.

Injury

Where irises are grown in soil with faulty drainage or in shaded, protected beds the plants seem to suffer more severely from the attack of the iris-borer than where the plants are grown on hillsides or where the drainage is adequate. Infested plants may be detected during the growing season by the presence of an abnormal amount of dead, brown foliage. Where such foliage is present, an examination will often reveal a large flesh-colored "worm," or several of them, tunneling through the rhizome. The presence of these larvae is often accompanied by a bacterial rot which causes a breaking down of the tissue and reduces the interior of the root to a slimy mass. Roots in such condition, of course, cannot be expected to produce healthy foliage. Furthermore, such decaying roots are very attractive to the lesser bulb-fly. Many adults of the lesser bulb-fly were bred from such iris rhizomes received from different parts of the State.

Control

Grow iris in open plantings on well-drained soil. Hillsides and well-drained beds usually produce vigorous plants.

Iris-borer is seldom a problem where the plants are transplanted every third year.

Many eggs of iris-borer are destroyed if the plantings are cleaned up early in the spring and the dead leaves burned.

Watch plantings during June and early July for evidence of leaf-miner injury. In small plantings or on high-priced varieties, the tiny borer may be crushed by hand, without injury to the plant, before it gets down into the rhizome.

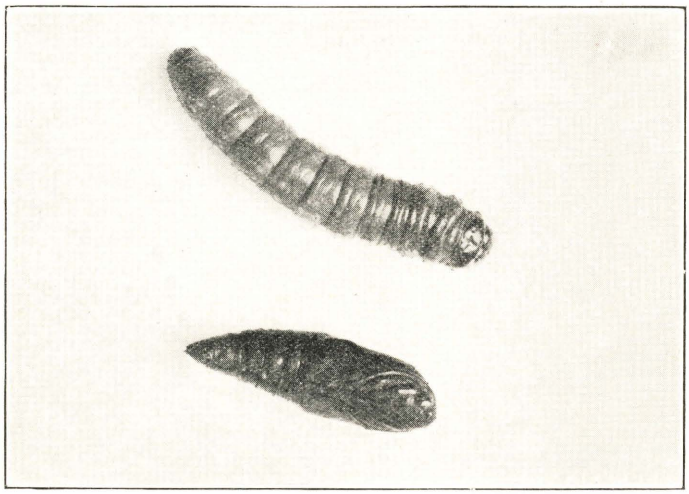

Fig. 12.—Larva and pupa of Iris-borer.

The larvae are difficult to kill after they become established in the rhizomes. Where expensive rhizomes are infested, they may be saved by the use of a contact insecticide. There are several contact insecticides which have been recommended, and of these the pyrethrum preparations have apparently been the most satisfactory. We have been successful with the corrosive sublimate treatment (see page 7). Follow directions, taking special care to get as little liquid on the foliage as possible. Where a contact insecticide is used, it is necessary that the rhizome be opened up so that the insecticide comes in contact with the larvae.

Where the rhizomes are severely infested, they cannot be profitably saved. In such cases, it is advisable to dig them up and destroy them.