

# VIRGINIA TRUCK EXPERIMENT STATION BULLETIN

JULY 1, 1927

NORFOLK, VIRGINIA

---

---

Published Quarterly

by

THE VIRGINIA TRUCK EXPERIMENT STATION

T. C. Johnson, *Director*

---

## Truck Crop Investigations

---

### THE BULB FLIES OF NARCISSUS WITH SPECIAL REFERENCE TO THE BULB INDUSTRY IN VIRGINIA

---

BY

F. W. POOS and C. A. WEIGEL

---

---

## ORGANIZATION

# Virginia Truck Experiment Station

---

BENJAMIN T. GUNTER, President.....Accomac, Accomack County  
JULIAN A. BURRUSS.....Blacksburg, Montgomery County  
T. B. GRIFFIN.....Churchland, Norfolk County  
DANIEL W. LINDSEY.....South Norfolk, Norfolk County  
R. S. MOSS.....Burkes Garden, Tazewell County

---

## STATION STAFF

T. C. JOHNSON, A. M.....Director, Horticulture  
H. H. ZIMMERLEY, B. S.....Horticulture  
M. M. PARKER, B. S.....Horticulture  
FRANK P. McWHORTER, Ph. D. .... Pathology  
F. W. POOS, Ph. D.....Entomology  
W. O. STRONG, B. S.....Entomology  
H. S. PETERS, M. S.....Entomology  
G. R. GARDNER.....Horticultural Foreman  
H. M. MEARS.....Foreman Eastern Shore Sub-Station  
ALDA C. LUPRE ..... Clerk and Stenographer

---

The Virginia Truck Experiment Station is located on the Cape Henry trolley road, six miles east of Norfolk. Visitors are welcome at all times and will be given every opportunity to inspect the work of the Station.

Copies of the Station publications will be sent free to all residents of the State who apply for them. Address all communications to the Virginia Truck Experiment Station, Norfolk, Virginia.

# THE BULB FLIES OF NARCISSUS WITH SPECIAL REFERENCE TO THE BULB INDUSTRY IN VIRGINIA

By F. W. POOS<sup>1</sup> and C. A. WEIGEL<sup>2</sup>.

## INTRODUCTION

The Narcissus bulb fly, *Merodon equestris* Fab.,<sup>3</sup> often referred to as the daffodil fly, and the lesser bulb flies, *Eumerus*<sup>3</sup> spp., have long been recognized as the most serious insect pests of the Narcissus in Europe. The entry of these pests into the United States with Narcissus bulbs, together with the entry with such bulbs of other pests dangerous both to bulbs and to other cultivated plants, led to the promulgation by the U. S. Department of Agriculture of a quarantine, effective January 1, 1926, greatly restricting the entry of Narcissus. Under the quarantine, entry is limited to such importations as may be necessary for propagation, for the introduction of new varieties, or for any necessary experimental or scientific purpose—all such entries to be made through the U. S. Department of Agriculture and under adequate controls, including the disinfection of the bulbs by hot water.

There have been fairly extensive plantings of Narcissus, chiefly in the Atlantic coastal plain, some of them dating back nearly a hundred years. These plantings have been largely free from the common bulb pests and have been used mostly for cut flowers. The existence of these plantings and other widely scattered plantings indicate that suitable soil and climatic conditions for the production of Narcissus bulbs for forcing occur in various sections of the United States, and during the past few years considerable interest has developed in the production of Narcissus for the purpose of producing a supply for forcing. The discussions in this paper have special reference to the production of such forcing stock in the tidewater region of Virginia.

The region of tidewater Virginia, which for the past twenty-five years, has had a number of naturalized plantings\* devoted entirely to flower production has rapidly developed the new industry of growing bulbs for forcing and planting stock during the past two seasons because of the decided advantages which are found here with reference to soil, climate, transportation and accessibility to

(1) Names of authors arranged alphabetically.

(2) Entomologist, Tropical and Subtropical Plant Insect Investigations, U. S. Bureau of Entomology, Washington, D. C.

(3) Order Diptera, Family Syrphidae.

(\*) This stock was lifted about every three or four years in order to obtain the best results.

markets. As evidence of this, fifteen growers in Virginia applied for field inspection of Narcissus bulbs during the season of 1926. According to French (18)\*\* these plantings were largely in Princess Anne, Norfolk, Sussex, Matthews and Gloucester Counties and comprised a total of about 300 acres which were conservatively estimated to contain twenty-five to thirty million of these bulbs. In addition the records of the Federal Horticultural Board show that over three million Narcissus bulbs were imported into Virginia under special permit during the season of 1926.

The tremendous expansion in the Narcissus bulb industry during the past few years and the fact that some of the planting stock imported prior to the placing of the restrictions was infested with bulb pests, has increased the risk of these pests becoming established, especially in the old, uninfested naturalized plantings. As a result of the widespread interest in bulb production, naturally the interest in bulb pests has also increased. It was, therefore, considered advisable to review the history of the bulb flies, both in Europe and in this country, as a back-ground and to give some pertinent facts in connection with these insects for the benefit of Eastern bulb growers, especially, and for the protection of the bulb industry. A review of the American literature soon revealed the fact that entomologists apparently had given little attention to these pests from the point of view of life history studies and control measures prior to the fall of 1924 when a detailed study of the Narcissus fly was started by Weigel (46) at Washington, D. C., and at the same time Broadbent (6) began the study of the life history of the lesser bulb fly. The literature on the bulb flies goes back nearly 200 years and has been aptly described by one writer as being voluminous. Apparently these species have been reported from every country in the world where Narcissus are grown and have been thus widely distributed by shipments of infested bulbs. Several hundred references have been consulted in the preparation of this paper but it was considered feasible to list only the more important ones which relate directly to the subject under discussion. Each species will be treated separately except under the discussion of control.

## THE NARCISSUS BULB FLY (*Merodon equestris* Fab.)

### History and Economic Importance.

Reaumur (35) in 1738 was apparently the first to record this insect pest in literature when he reported that some Narcissus in France taken from the ground in November contained a large boring worm and in some cases two worms. Adult flies were se-

(\*\*) Reference is made by number to "literature cited", p. 590.

cured from these the following April. The species was described by Fabricius in 1792 as *Syrphus equestris*, afterward placing it in the genus *Merodon*. On account of the variability of the color markings of the insect it has received a number of synonyms, among which appear to be *Merodon flavicans*, *M. cinereus*, *M. narcissi*, *M. ferrugineus*, *M. transversalis*, *M. constans*, *M. nobilis*, *M. tuberculatus* and *M. bulborum*. Verrall (43), the British authority on the order Diptera or the flies, reports that *Merodon* is an old-world genus originally from Southern Europe and that about 50 different European species are known. Also, that serious damage was done to Narcissus bulbs in Cornwall in October, 1896, when one gardener alone had been compelled to destroy several thousand Narcissus while many other records had been given in recent years of similar damage done near London and in other districts where bulbs are extensively cultivated. As for *M. equestris* Fab., the records seem to indicate a progressive movement of this pest from Spain to France, Holland and Belgium, reaching England about 1869. It was reported as a pest in Holland as early as 1840. The importance of this insect as a serious pest of the Narcissus is not questioned, as a bulb once attacked is nearly always entirely destroyed. It has been reported in bulbs other than the Narcissus but such occurrences are not common.

Wilks (51) in 1901 states the following in regard to its importance: "The enormous increase in recent years of the growth of Daffodils has brought with it a terrible increase in the number and distribution of this pest." This author also believed that it always seemed to attack the rarest and most valuable varieties.

This insect gradually became more common in England apparently because of large importations of infested bulbs from the South of Europe. In 1910 (1) it was scheduled as a pest of importance by the Board of Agriculture, under the powers conferred upon them by the Diseases and Pests Act, and those in whose plantings it was found were bound, under a penalty, to report its occurrence to the Board while certain Counties prohibited the importation of the Narcissus unless they were certified to be free from the Narcissus fly or to have come from fields where the fly was unknown. MacDougall (27) reported in 1913 great destruction of the Narcissus in different parts of Scotland and that the adult bulb flies had often been caught in large numbers. Dr. Van Slogteren (40) in 1920 reported great damage in England and that in Holland there were places where growing of Narcissus was practically impossible on account of this pest. According to Govt Gaz. No. 97, July 17, 1925, Sydney Australia, the Narcissus bulb fly was declared to be a pest, under a proclamation of the Plant Disease Act of 1924 in New South Wales.

Apparently the first reference to this insect in American writings was by Packard (32) when he reported that a Mr. Sanborn reared it from the pupa which he described. He stated that it had been introduced from Europe by the Importers of Dutch bulbs. Jack (25) stated that in the Agassiz Museum at Cambridge, Massachusetts, there were larvae of this pest and damaged bulbs of the Narcissus which were received from a garden in Brookline, Massachusetts, in 1879. He also reported that during the year or two previous to 1897 the same establishment suffered more than usual damage from the ravages of the *Merodon* which he says "appears to have been present in more or less abundance every season since it was first introduced in the place nearly 20 years ago." Osburn (31) considered this insect a native species in British Columbia in 1908 where adults were abundant and often frequented the flowers of the Salmon-berry (*Rubus spectabilis*). In 1911 Hewitt (23) reported this insect noticeably present in British Columbia where it was a serious pest of bulbs; that Mr. A. E. Wallace reported it as attacking the Narcissus near Victoria, B. C., about 50,000 bulbs having been destroyed in the year. Apparently it was first reported in Canada at Mount Royal, Montreal, by Mr. G. Chagnon in 1903. Tullgren (39) reported *M. equestris* injuring the bulbs of daffodils in Sweden during 1912-1916. Childs (8) in 1914 first records the occurrence of the pest in California where it was collected in bulbs of amaryllis by B. B. Whitney, San Rafael, Calif. The specimens were determined by Dr. J. M. Aldrich of the U. S. National Museum. In 1915 Treherne (38) gave warning that this insect was rapidly increasing its sphere of prevalence in British Columbia, because he had observed an extraordinarily bad attack from it just outside the city limits of Vancouver. He reported that it had increased to a remarkable extent during the three preceding seasons. Riley (36) reported a shipment of 3,000 Narcissus from Holland in 1919, 20% of which were infested with this pest. Weiss (49) reports it is probably established in New Jersey. Many records of its interception have been reported in imported Narcissus at various places in the United States. Schoene (37) reports that it was intercepted in bulbs imported into Virginia during the autumn of 1919.

These reports should be considered as records of interceptions and should be distinguished from established continuing infestations. The wide distribution of the infested bulbs has apparently not resulted in general establishment of the pest throughout the United States. The Bureau of Entomology is now engaged in determining the actual distribution and establishment of this insect in the United States, and this information will probably be published when the survey is completed.

## DESCRIPTION OF STAGES

The description of the Narcissus fly given here is intended only for the use of the grower and not for technical purposes. The adult (Fig. 102, C and 103, N) is a large two-winged fly from  $\frac{3}{8}$  to  $\frac{1}{2}$  inch long. The name *Merodon* signifies "tooth on femur" and this pest possesses a broad toothlike process on the underside of the thighs (femora) of the hind legs, near the tip. The male also possesses a sharp spur at the end of the tibia of the hind leg. The coloring of the flies, because of the great variation, is difficult to describe. They resemble bumblebees not only in size and color but in their actions. Usually they appear to have black bands across the thorax and abdomen, the remainder of the thorax being covered with orange colored hairs, and the abdomen with tan. These bands, however, are sometimes lacking and many different combinations of yellow, orange and tan marking are also found. The eyes are very large, appearing to form the principal part of the head. They have moderately hairy eyes and black legs. The wings are somewhat short and rounded. The entire body is very hairy. The narrower body, the presence of only two wings, and the very active spasmodic lateral movement will serve to distinguish it from a bee.

Eggs: The eggs (Fig. 102, K) are small, elongate, oval and white. They are about  $\frac{1}{16}$  inch in length.

Larvae: The newly hatched larva is small, white and rather inconspicuous. The older larvae or maggots (Fig. 102, E and F) are dirty white or grayish yellow, legless, and from  $\frac{1}{2}$  to  $\frac{3}{4}$  inch in length when full grown. They have a dark red-colored, knob like projection (the breathing spiracle) at the rounded hind end of the body. On each side of this is a short spiny horn. The body is stout and rounded and the joints are well marked. It is arched on the upper side and flattened on the under surface.

Pupae: The puparium (Fig. 102, D) is elongate, grayish brown, distinctly segmented with posterior projecting spiracles still visible. It is about  $\frac{1}{2}$  inch in length.

## LIFE HISTORY

All data upon the biology of the Narcissus fly in the United States indicate that there is only one generation annually. Some European writers, however, claim to have observed a two-year life cycle for this pest. The winter is passed as full grown larvae in the bulbs. Larvae collected in bulbs received from Holland in November, 1926, pupated under insectary conditions at Norfolk, Virginia, in March, 1927. Only a few specimens were available and no adults emerged due to interference with the pupae by ants. The larvae leave the bulbs and pupate in the soil. The pupa usually occupies an almost vertical or somewhat slanting position with

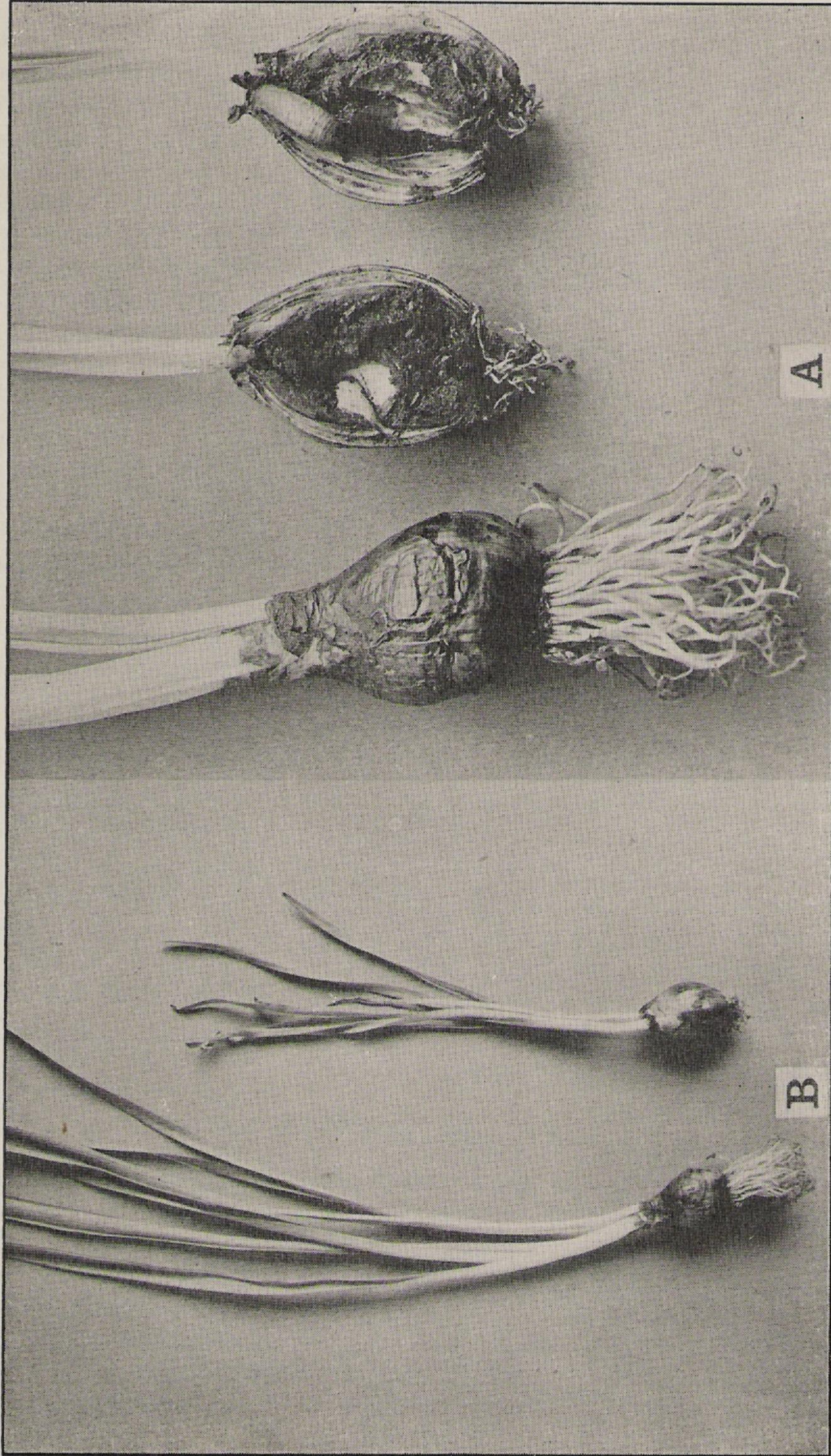


FIGURE 101

A—At left, normal uninfested bulb. At right, bulb dissected to show injury by larva of the Narcissus fly, *Merodon equestris* Fab. B—At right, Golden Spur bulb shows effect of infestation by the Narcissus fly in foliage and root growth; at left, normal uninfested bulb.

its head end about level with the surface of the soil, so that it is in contact with the air, (Fig. 102, G and H). The tip of the head is exposed and the breathing spiracles are clearly discernible while in this position. Fig. 102, H shows a puparium in the soil from which an adult has emerged. On April 24, 1926, unmistakable evidence of recently emerged Narcissus fly was found in a few bulbs in one of the plantings of Narcissus in tidewater Virginia, showing that adults had emerged by that date. The following life history data were reported by Broadbent (7) at Washington, D. C., under outdoor conditions:

The larval stage requires about 10 months. Pupation occurred from March 25 to April 17 in 1926, and the pupal stage required 5 to 7 weeks. Adults emerged May 8 to May 22 and some lived for four weeks although the average was about 16 days. Seventy-five percent emerged between daylight and 9:00 A. M. Mating occurred only in bright sunlight beginning the day after emergence. Each female deposited nearly 100 eggs and began depositing within 1 to 6 days after mating. The eggs were usually deposited between the sheath and stem of the bulb or between the layers of skin enclosing the neck of the bulb. They are sometimes found in crevices in the soil. Eggs were laid singly or in groups of 2 or 3 or more. Egg laying took place only during the daytime and rarely on cool, cloudy days. The incubation period was 10 to 14 days. The larvae grew most rapidly during the first two months, and appeared to be full grown before cold weather set in.

Weigel (46) found that extracted honey proved to be a suitable food for the adults under cage conditions and that sunlight and food appeared to be a prerequisite for mating and egg deposition. In the field this insect apparently feeds on the nectar of flowers and its first natural instinct is to go in search of food. This habit is probably responsible for the perishing of many adult flies before they find opportunity to breed in regions where growing of Narcissus is not general or common. Weigel (46) also observed for the first time that the newly hatched larva worked its way down through one of the outer bulb scales to the basal plate through which it apparently bored its way into the interior of the bulb. This phase of the life history of this insect has been the subject of much discussion, apparently based on superficial observation, in European literature.

The observations reported above indicate that the seasonal development of the Narcissus fly in the Eastern part of the United States agrees substantially with the development reported by most writers in Holland and England. It also indicates that this species is capable of living over from year to year in case it becomes permanently established in our domestic bulb plantings.

## NATURE OF INJURY

The newly hatched larvae of the Narcissus fly begin feeding in the basal plate and later bore into the center of the bulbs causing a bad discoloration (Fig. 102, F). The actual damage is done by the larvae which often destroy more than they eat by tunnelling in the bulb. The center of the bulb is usually hollowed out (Fig. 101, A) and the flower bud consumed so that only a mass of wet frass and decayed matter remains. The bulb usually rots completely and no root development takes place (Fig. 101, B). A larva may occasionally leave one bulb and enter another. Their presence is often quite difficult to detect, particularly while larvae are small. One method is to squeeze the bulbs near the neck when they are dug and if they "give" to the pressure of the hand they are almost certain to be hollowed out by the maggots. Infested bulbs usually have a somewhat sunken and corky basal plate which, if closely examined, will reveal the entrance hole of the larva. There is usually but one maggot in a bulb, but occasionally two or three may be found. Sometimes the splits are attacked and the center bulb left alone but the contrary is usually true. The lesser bulb fly is sometimes associated with it in the same bulb. Norman (30) states that the true Narcissus type is most susceptible to attack and then come the intermediate season daffodils. He believed *N. poeticus recurvus* and *Barii conspicuus* to be most subject to attack, followed by *N. poeticus ornatus*, Poetarum, Sir Watkin, Mrs. Langtry, Van Sion, and Emperor, while Henry Irving, Golden Spur, and Princeps were considered almost free as were the late daffodils. Bos (3) in 1886 reported that this pest attacked chiefly *Narcissus tazetta* and Jonquillas in Holland, as these varieties were covered deepest with soil in winter. Fryer (20) reported that the hard bulbs of *Narcissus maximus* and *N. spurius* were least attacked while *N. poeticus* and *N. Leedsii* were most susceptible; also, that varieties with colored cups were more susceptible than those without. In bulbs imported into Virginia from Holland during the past two seasons the varieties of Victoria and Emperor seem to have shown the heaviest infestations.

## HOST PLANTS

The Narcissus fly has been reported from the following host plants according to various references consulted in the American and European literature: amaryllis (*Hippeastrum* or *Habranthus*), daffodil, *Eurycles* (Brisbane lily), *Galtonia* (Giant Summer Hyacinth), *Galanthus nivalis* (snowdrop), hyacinth, *Iris xiphium* (Spanish Iris), *Iris xiphium x tingitana* (Dutch Iris), *Iris tingitana* (French Iris), lilies, *Leucojum*, *Narcissus*, *Scilla nutaris* (Wild Hyacinth), tulips and *Vallota purpurea* (Scarborough lily).

## THE LESSER BULB FLY (*Eumerus strigatus* Fallen)

### History and Economic Importance

Cole (10) in 1920 gave the latest published synonymy of the lesser bulb fly. According to this it was first described in 1817. Much difference of opinion has been expressed as to whether this species is capable of attacking sound bulbs or whether it is merely a beneficial scavenger. The fact that it has been reported from a great variety of host plants suggests strongly the possibility of two or more different species, and also the Narcissus fly, being mistaken for *Eumerus strigatus*; or there may be biological races of the same species as suggested by Cole (10). The Bureau of Entomology has recently undertaken a biological study to determine this point and at the present time Dipterists are loathe to give a synonymy of this species which they consider authoritative. Hodson (24) in a recent paper states that 90% of the injury to bulbs in Southwest England by the small flies is due to *Eumerus tuberculatus* Rond. which is similar in habit to *E. strigatus* and can be distinguished from it only in the adult stage. It is an European species and the larvae were recorded as feeding on the roots of cabbage in England as early as May, 1841, by Curtis (12). Apparently it was previously reported as a pest of onions, as he states "the maggots of this fly do not seem to be confined to the onion." In 1845 Dufour (16) reported an infestation by this pest in onions in France. Two years later Bouche (5) reported that "It lives in July in the bulbs of common onions, *Allium cepa*, which it destroys completely. At times they destroy the entire crop". Verrall (44) in 1901 states that it is recorded from all North and middle Europe and also from Italy.

In 1913 MacDougall (27) reported that the fly did great damage to onions on the continent in 1847 and that the larvae have also been found in shallots and that Theobald found them in bulbs of hyacinth. In 1915 Herold (22) recorded that the tubers of potatoes were badly destroyed by the larvae of this species. Fryer (19) in 1914 reported that this species had only recently become a serious pest of the Narcissus in England, although widely distributed on the continent. Vassiliev (42) reported it as a pest of onions and garlic in Russia in 1914. Bos (4) in 1917 reported that the larvae of this fly occurred in the Narcissus in Holland and sometimes also infested onions and shallots. In 1919 Zacher (52) reported it as a primary pest of rotting potatoes in central Europe. Wahl (45) in 1920 recorded it among the more important animal pests of the common vegetables in Austria. Collin (11) in 1920 reported that plants chiefly attacked in Britain were the Narcissus, iris and lilies; that onions were rarely attacked and that parsnips were apparently much damaged upon one occasion. Bogdanov-Katkov (2) in 1921 reported it as a pest in Russia.

The first American record of this species which was published was apparently by Johnson (26) in 1910 about specimens taken in 1908 and 1909, although Gibson (21) in 1917 reported the earliest known capture of this species at Ottawa, Canada, in 1904 by Dr. Fletcher. In 1912 Felt (17) reported this species reared from iris roots in New York; also, that Dr. Chittenden reared this species in 1906 at Washington, D. C., from bulbs which were sent to him from New York, Connecticut and Texas. Davidson (13) in 1915 first recorded the presence of this species in California. Metcalf (29) in 1916 first collected this species in Maine. In discussing the distribution of this species this author says, "I believe that this species, like its companion in habit, *Merodon equestris*, is thoroughly established in widely separated regions of this continent \* \* \* \* that it constitutes a real and totally unappreciated menace to the interests of horticulturists, florists and onion farmers. It will be very surprising if we do not have a sudden and severe outbreak of one or both of these pests when they have become a little more thoroughly acclimated and have experienced a period of conditions favorable to their rapid increase in numbers." Schoene (37) in 1920 reported the interception of this species in Virginia in Narcissus from Holland. Cole (9) first recorded this fly damaging onions in the United States at Hood River, Oregon, in 1918. Mackie (28) reported this insect taken on sixteen different hosts in California and stated that, in 1925, limited digging in a planting in Santa Cruz County showed that 25% of the Golden Spur, King Alfred and Van Waveren Giant varieties of Narcissus carried larvae of this fly. He also states that it is less common in hyacinth than in Narcissus, although about 10% of the hyacinths in Capital Park, Sacramento, are annually destroyed by it. These records indicate distinctly the possibilities of this insect as a pest and that it is just beginning to multiply and become abundant enough to demonstrate such possibilities.

As bearing on the parasitic nature of this pest, most American writers do not believe from their observations that the decay is primary and the infestation secondary. Fryer (20) who made perhaps the most accurate observations on this insect among the European writers and whose studies involved examinations of many hundreds of bulbs infested with this fly, concludes "that there is little evidence to justify the assumption that *Eumerus strigatus* is a harmless scavenger." Broadbent (6) states that the female flies deposited their eggs on sound bulbs and the larvae are equipped with rasping mouthhooks (Fig. 103, L) which are capable of scraping healthy tissue and of burrowing under the epidermis of the bulb scales. Weigel, in 1925, found that when these flies (fed and matured) were given, in cages, a choice of both sound and rotting

onions and Narcissus bulbs, they deposited eggs only on the healthy bulbs and never in decaying bulbs. The larvae which hatched from these eggs developed normally into adults in firm and sound onion and Narcissus bulbs. These flies in turn gave rise through subsequent breeding to a successful second and a partial third generation, all in sound bulbs of onion and Narcissus. These data would seem to indicate that the lesser bulb fly is not a mere scavenger.

This fly is thought to be established in New York, New Jersey, Massachusetts, Connecticut, North Carolina, Virginia and the Pacific Coast States. However, as in the case of the Narcissus fly, its distribution throughout the United States is being determined by the Bureau of Entomology.

### DESCRIPTION OF STAGES

The following description of the lesser bulb fly is intended only to aid the bulb grower to recognize this pest in all of its various stages:

Adults: The adults (Fig. 103, M and P) are two-winged flies, about  $\frac{1}{3}$  inch in length and the body and legs are more or less robust. The body is densely clothed with very short hairs and is thickly and distinctly pitted. The metallic bronze colored body of the flies glistens in the sunlight. The abdomen is black except for yellowish hairs at the tip and is marked with three crescent-shaped grayish white bands, and there is a white line on each side of the thorax. (Fig. 103, P). The males are usually smaller than the females and their eyes touch for a short distance just above the antennae while the eyes of the female are widely separated. The thighs (femora) of the hind legs are thick and are usually rather conspicuous.

Eggs: The eggs (Fig. 102, I) are white in color and average about  $\frac{1}{64}$  inch in length by about  $\frac{1}{3}$  as much in width. They are subcylindrical in shape, one end tapers to a point and the other is rounded. The covering of the eggs is quite delicate and easily ruptured. The eggs are much smaller than those of the Narcissus fly.

Larvae: The full grown larvae (Fig. 102, J) average about  $\frac{1}{4}$  to  $\frac{1}{3}$  inch in length. They are usually a dirty grayish yellow color but this varies somewhat depending upon the color of their food. They are extremely wrinkled, clothed with minute spines, and somewhat flattened vertically. The posterior respiratory process projects prominently as a horny tubercle and is usually brick red or chestnut colored. They have a characteristic and prominent tubercle on each side of the posterior respiratory process. It is thus easy to distinguish these larvae from any other to be found in bulbs.

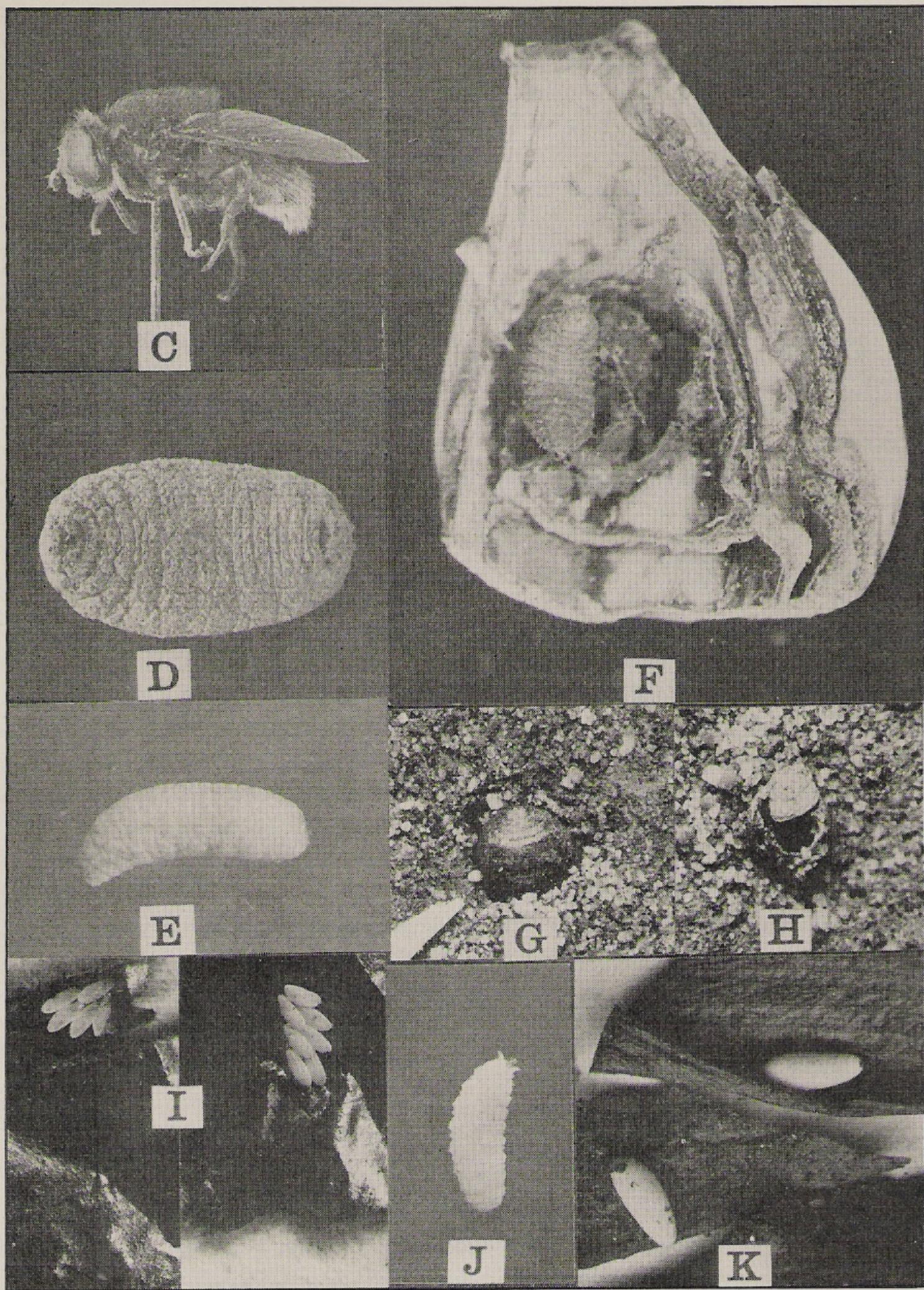


FIGURE 102

C—Adult Narcissus fly, *Merodon equestris* Fab. Enlarged about 3 times. D—Puparium of Narcissus fly, enlarged about 3 times. E—Larva of Narcissus fly, enlarged about 2 times. F—Larva of Narcissus fly, showing injury to bulb. Slightly enlarged. G and H—Puparia of Narcissus fly in natural position in the soil. The adult fly has emerged from the puparium on the right. Enlarged about 2 times. (After Weigel). I—Eggs of the lesser bulb fly, *Eumerus strigatus* Fallen. Enlarged about 12 times. (After Broadbent). J—Larva of a lesser bulb fly, *Eumerus* sp. Enlarged about 3 times. K—Eggs of the Narcissus fly, *Merodon equestris* Fab. Enlarged about 8 times. (After Weigel.)

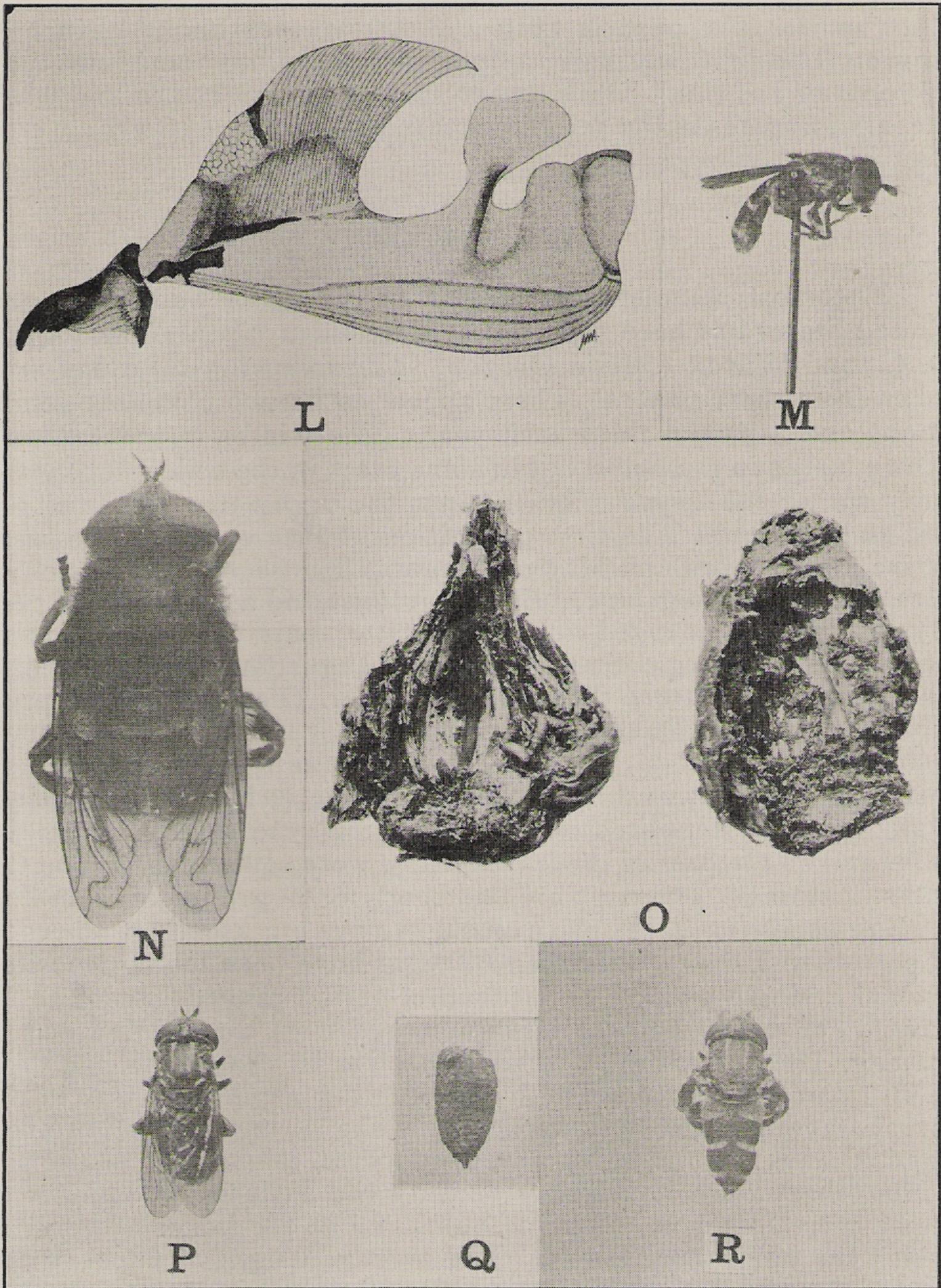


FIGURE 103

L.—Cephalopharyngeal skeleton of larva of *Eumerus strigatus* Fallen showing chitinized mouth hook. Greatly enlarged. M—Lateral view of adult of the lesser bulb fly, *Eumerus* sp. Enlarged about 3 times. N—Adult of the Narcissus fly, *Merodon equestris* Fab. Enlarged about 5 times. O—Bulb injured by the larvae of the lesser bulb fly, *Eumerus strigatus* Fallen. (After Weigel and Sasser). P—Dorsal view of the adult of the lesser bulb fly, *Eumerus* sp. Enlarged about 3 times. R—Same, with wings removed to show markings on thorax and abdomen. Q—Puparium of the lesser bulb fly, *Eumerus* sp., from which adult has emerged. Enlarged about  $2\frac{1}{2}$  times.

Puparia: The puparia (Fig. 103, Q) average about  $\frac{1}{4}$  inch in length. The color is usually a light, dirty gray but sometimes with a brown or red tint. The exterior surface is very rough and when the larva pupates in the soil the puparium is almost entirely covered with fine particles of soil.

### LIFE HISTORY

The most complete life history of the lesser bulb fly in the United States has been reported by Broadbent (7) at Washington, D. C., and Wilcox (50) in Oregon. The following information is taken from these papers. There appear to be two complete generations and a partial third each year. The winter is spent as full grown larvae in the bulbs, but in some cases in the soil. During the early spring the larvae migrated into the upper two inches of the soil and pupated. The first generation of flies emerged and were active during April and May in Oregon. The second generation of flies emerged during June, July and August and a partial third generation of flies emerged during the latter part of August and in September. The eggs that were laid in August and September produce most of the larvae that pass the winter. The eggs are laid principally in the soil adjacent to the plant, the majority being about  $\frac{1}{4}$  inch under the surface. The flies crawl down into cracks and deposit their eggs as much as three inches below the surface of the ground. Many eggs are deposited on and under the dead skin covering the bulbs and on the base of the leaves. Eggs were sometimes laid on the bulbs in storage. The eggs are laid singly or in groups of from 2 to 40. Egg deposition takes place on sunny days but usually in the cooler part of such days. More than 100 eggs have been found deposited around a single plant. The incubation period ranged from 5 to 10 days. The newly hatched larva emerged from the pointed end of the egg. The larvae outdoors were inactive all winter and had their mouth parts retracted. The over-wintering generation was in the larval stage about seven months while the spring generation averaged 30 days. Some puparia were found on the surface of the soil while others were four inches beneath the surface. A number of pupae were found in or on the bulbs and in the boxes or trays in which the bulbs were stored. The average length of pupal period for the over-wintering generation was 30 days with a maximum of 40 and a minimum of 18 days. The pupal stage of the summer generation ranged from 7 to 14 days. At Washington, D. C., in August, 1924, the pupal period of 66 specimens ranged from 8 to 16 days and averaged 11.5 days. Most of the adult flies emerged at night. When they were fed extracted honey on the wire of their cages, they lived an average of about 3 weeks, the maximum period being

36 days. Cool, humid conditions were the main requirements for keeping the flies alive. Mating took place in bright sunlight but could be induced by artificial light on cloudy days.

A survey of the plantings of Narcissus in tidewater Virginia in August, 1925, yielded evidence of slight infestation by this species in two widely separated plantings. In 1926, larvae and pupae of this species were found on April 24th, in a few bulbs in two plantings in Matthews County. On April 23rd plants in the vicinity of Norfolk were examined with negative results. On April 26th, however, in the same plantings there were found both male and female adult flies on the wing. Emergence had apparently just begun. Because of the unusually cool weather on this date several flies were captured easily along the ground and among the foliage. A few visits to these plantings during May gave no further evidence of this species. On July 24th a few larvae and pupae of this species were found in bulbs of the Victoria variety which had been dug for inspection. The first adult emerged July 26th and adults continued to emerge from this material until August 8th. Sixteen adults emerged from one bulb and were placed in a breeding cage to continue their life cycle. Nothing was reared and this was apparently due to lack of proper care in feeding the adults. On April 14, 1927, a few adults of this species were collected in the Norfolk-Portsmouth section, although no further evidence of this species was noted at any other time in any of the plantings of Narcissus in tidewater Virginia up to August 1, 1927. It should be stated that no great amount of time was available for making a large number of detailed observations.

### NATURE OF INJURY

The lesser bulb flies are often the cause for the lack of leaf growth of plants in the field and infested bulbs may usually be detected by examining vacant places in the row. Sometimes stunted leaves appear when the bulbs have not been entirely killed. The larvae usually begin to attack the bulb at the base but sometimes only the neck of the bulb is attacked. After entering the bulb they feed in the interior which soon becomes slimy and full of a semi-liquid decaying mass (Fig. 103, O). Generally the basal plate becomes entirely rotted in heavily infested bulbs. Bulbs so infested are entirely destroyed with nothing but the outside layers of skin remaining. Usually 10 to 30 larvae are found inhabiting one bulb. Doucette\*, of the U. S. Bureau of Entomology, reported as high as 558 maggots in one bulb of the Van Waveren Giant variety in September, 1925. This species is sometimes found in the same bulb with

---

(\*) Unpublished notes.

the Narcissus fly, *Merodon equestris*. This is probably responsible for many conflicting statements in the literature regarding the habits of these species.

### HOST PLANTS

The lesser bulb fly has been reported from the following host plants according to the various references consulted in the American and European literature: Amaryllis, cabbage roots, yellow calla (*Calla elliottiana*), *Eurycles*, *Galtonia*, garlic, *Gladiolus*, hyacinth, iris rhizomes, iris bulbs, *Iris xiphium*, *I. xiphium* x *tingitana*, *I. tingitana*, *I. pogoniris*, *I. susiana*, *Ismeme calathina*, lilies, Easter lily, (*Lilium longiflorum*), gold banded lily (*Lilium auratum*), *Lilium candidum*, *Lilium speciosum*, Narcissus, onion (*Allium cepa*), parsnip, *Scilla*, shallot (*Allium ascarlonicum*), *Sprekelia formosissima*, and *Vallota*.

### CONTROL

Control measures for both species of flies are similar and are, therefore, discussed together. European writers have suggested many methods of control, such as collecting the adult flies (which are more or less inactive when the temperature is comparatively low) in nets and destroying them; early lifting of bulbs and drying as quickly as possible in order to kill the young larvae; careful sorting and picking out of the defective bulbs and burning them; roguing and destroying weak, sickly plants in the field in early spring in order to remove infested bulbs; clearing off all foliage after it has dried and fallen; disturbing or working the soil in order to fill up the holes, which thus prevents the female flies from depositing their eggs within easy reach of the bulbs below; the application of various deterrents for the purpose of preventing the flies from depositing their eggs upon the bulbs; soaking in water for a week or treating in various chemical solutions; covering small lots of choice stock with a thin, silk cloth to protect the bulbs from egg deposition; trapping and baiting adults. Field control experiments in the United States, however, have not proceeded far enough to permit any definite recommendations being made at this time.

The control method which has been used extensively in Europe and has accomplished the most is the annual lifting of the bulbs and the destruction of all those which are found to be infested. As an additional safeguard, suspected stock is subjected to the hot water treatment, a method developed by Ramsbottom (34) of England and Van Slogteren (41) of Holland. Essentially this treatment consists of the immersion of the bulbs in water kept at a temperature above 110 degrees F. and under 111.5 degrees F. For the control of the nematode or eelworm, this immersion must continue for at least two and one-half hours, and this time must be calculated

from the time when the temperature of the whole mass becomes equalized. For the control of the bulb flies Doucette (14) shows that immersions of 40 minutes or longer in water at 110 degrees F. results in 100% mortality of the larvae of both species. The hot water treatment is being required at present by the Federal Horticultural Board for all imported Narcissus and also for all domestic stock moving interstate which is found to be infested.

The hot water treatment is not to be considered a method of complete eradication of the bulb flies, as there are several sources from which bulbs may become reinfested. It serves, however, to reduce the population of the insects considerably and assures the grower that his planting stock is clean.

Many factors in connection with this treatment remain to be thoroughly worked out, such as the influence of the size of bulb, varietal differences, conditions of handling and drying, and climatic effects. It is known that there is considerable latitude possible with this treatment, but the optimum conditions for it are not yet definitely determined. In 1927 Doucette (15) made a preliminary report on experiments in central California which indicated that July 20th to 30th was the best period for treatment of bulbs in that section. He also reported that bulbs treated at 114 degrees F. for three hours at the above season apparently made a more satisfactory growth than bulbs treated during September at 110 degrees F. Weigel (47, 48) has shown that Paper White and Trumpet Narcissi can be forced with fairly satisfactory results after hot water treatment if proper precautions are followed.

### HOT WATER TREATMENT AT NORFOLK

Because of the meager data available upon the effect of the hot water treatment upon the vegetative qualities of Narcissus in Virginia, some preliminary experiments were started in 1926. The bulbs grown by R. E. Thrasher & Sons for the United Bulb Company of Sassenheim, Holland, were kept under observation since being subjected to the sterilization October 27—November 15, 1926. The wholehearted interest in the work by these firms and the bulbs furnished for experimental work are gratefully acknowledged. The entire shipment of these imported bulbs was treated 2½ hours in hot water at a temperature of 110-111.5 degrees F. The treatment was not intentionally delayed but the importation of equipment and various circumstances prevented earlier treating. The following varieties were involved: America, Empress, Emperor, Elvira, Glory of Sassenheim, Golden Spur, King Alfred, Laurens Koster, P. ornatus, Princeps, Spring Glory, Sir Watkin, Sulphur, Victoria, Van Sion, Early, and Perfection. The results of treating so late in the season and planting without drying almost immediately after treat-

ment were awaited with interest. No ill effects on the vegetative qualities of any of these bulbs have been noted to date, (September 1, 1927) with the exception of the occurrence of a few abnormal blossoms in some of the Van Sion variety, which is reported by some to have a natural tendency to develop imperfect flowers.

As previously reported by Poos (33), about 400 bulbs of each of the following lots were planted on November 15, 1926, in an experimental plat: Victoria (round bulbs), Victoria (double nose), Golden Spur, Van Sion, Sir Watkin (round bulbs), Sir Watkin (double nose), Emperor, Laurens Koster. Each lot was planted in four separate rows, 100 bulbs to each row, from left to right as follows: check; no treatment; one-hour treatment; two-hour treatment; and three-hour treatment; all hot water treatments at 110-111.5 degrees F. The general condition of the foliage was good with a healthy green color except for a few varieties which showed some mottling in the leaves of the lots which had been treated for three hours. This, however, did not appear to be serious enough to be of any consequence and no deformed leaves were in evidence. The height of the foliage was apparently the same in the treated plats as in the untreated for all of the six varieties tested. The percentage of bloom was approximately the same in treated as in untreated plats. No injury to the basal plate which could be attributed to the hot water treatment was noted. In co-operation with the Staff Horticulturists, two examinations of the root systems were made in the fall and the general opinion prevailed that the treated bulbs contained a slightly better developed root system than the untreated bulbs on the same date. The treated bulbs showed foliage above ground slightly earlier than those which were untreated. There was, however, little difference in the time and period of flowering. These bulbs were dug on July 16, 1927, and 50 bulbs from each lot of each variety were weighed in order to compare the increase in the treated versus untreated. No differences could be noted. Although all the bulbs were treated very late in the season and were planted almost immediately after treatment, without being spread out to dry, they apparently developed very satisfactorily. The facts presented in this paper indicate that the hot water treatment is not a limiting factor in the development of the bulb industry in Virginia.

### SUMMARY

The most important insect pests of Narcissus in Europe are the Narcissus fly, *Merodon equestris* Fab., and the lesser bulb flies, *Emerus* spp. The entry of these pests into the United States with Narcissus, together with the entry in such bulbs of other pests dangerous both to bulbs and to other cultivated plants, led to the

promulgation by the U. S. Department of Agriculture of a quarantine, effective January 1, 1926, restricting the entry of Narcissus to such importations into the United States as may be necessary for propagation, for the introduction of new varieties, or for any necessary experimental or scientific purposes. All such imported stock is now subject to sterilization in hot water at 110-111.5 degrees F. for 2½ hours. To prevent the further dissemination of these pests in this country all domestic grown stock offered for interstate movement which on inspection is found to be infested is given the same treatment.

The bulb growing industry expanded greatly in this country during the past two seasons. Tidewater Virginia, where some Narcissus has been grown for commercial flower production for the past twenty-five years, was responsible for its share of producing bulbs for forcing and planting stock.

Little investigation of bulb pests had been done in America previous to 1925. The Narcissus fly which has been known in Europe since 1738, passes through one generation annually. On the other hand, the lesser bulb fly, which was first described in 1817 in Europe, passes through two complete generations and apparently a partial third generation annually in the region of tidewater Virginia. Various host plants are reported for these pests, but serious losses rarely occur except in the Narcissus. The lesser bulb fly *E. strigatus*, has been confused with one or more other species and much discussion has arisen as to whether it attacks healthy bulbs or whether it is merely a helpful scavenger. Recent work both in the United States and in England indicates that it will attack sound bulbs and should be considered an important pest. Apparently these pests have gained a slight foothold in certain sections of the United States. The U. S. Bureau of Entomology is at present engaged in studying their distribution. The evidence is not clear as the repeated occurrence of these pests in a vicinity where infested bulbs were imported every few years would permit the occurrence of these pests and not necessarily mean that there was a continuing infestation in the domestic bulb plantings.

The effect of the hot water treatment on the vegetative qualities of the Narcissus and their subsequent development under climatic conditions in tidewater Virginia was the subject of preliminary experiments beginning in the fall of 1926. These bulbs developed satisfactorily and it does not appear that treating will limit the production in Virginia.

## LITERATURE CITED

- (1) Anonymous.  
"Commonplace Notes." Destructive Insects and Pest Order of 1910. Jour. Roy. Hort. Soc. **36**: 153. 1910.
- (2) Bogdanov-Katkov, N. N.  
Petrograd Kitchen Gardening and Pests. Petrograd Kitchen Gardening, Petrograd, No. 1, pp. 47-48. 1921.
- (3) Bos, Ritzema J.  
La Mouche Du Narcisse. Arch. Musee Tyler, Ser. II, Part II, **2**: 45-95. 1886.
- (4) —————  
Diseases and Damages Caused by Animals. Meded. R. Hoogere Land- Tuin- en Boschbouwschool, Wageningen, XI, **5**: pp. 169-250. 1917.
- (5) Bouche von, P. F.  
Beitrage zur Kenntniss der Inseckten-Larven. Stettin Ent. Zeitung, No. 17, p. 145. 1847.
- (6) Broadbent, B. M.  
Notes on the Life History of the Lesser Bulb Fly, *Eumerus strigatus* Fallen. Jour. Ec. Ent. **18**: 141-143. 1925.
- (7) —————  
Further Observations on the Life History, Habits and Control of the Narcissus Bulb Fly, *Merodon equestris*, with Data on the Effect of Carbon Disulphide Fumigation on Three Bulb Pests. Jour. Ec. Ent. **20**: 94-113. 1927.
- (8) Childs, Leroy.  
The Large Narcissus Bulb Fly (*Merodon equestris* Fab.). Mo. Bul. Calif. Comm. Hort. **3**: 73-76. 1914.
- (9) Cole, Frank R.  
Emergency Entomogological Service, No. 11. 1918.
- (10) —————  
Notes on the Lunate Onion Fly, *Eumerus strigatus* (Dip. Syrphidae). Ent. News **31**: 31-35. 1920.
- (11) Collin, J. E.  
*Eumerus strigatus* Fallen, and *tuberculatus* Rondani (Dip. Syrphidae). Ent. Mo. Mag. London, England, No. 672, Third Ser., No. 65, May 1920, pp. 102-106.

- (12) Curtis, John.  
The Brassy Onion Fly, *Eumerus aeneus*. Gardeners' Chronicle **16**: 252. 1842.
- (13) Davidson, W. M.  
Occurrence of *Eumerus* (Syrphidae) in California. Can. Ent. **47**: 134-135. 1915.
- (14) Doucette, C. F.  
The Effect on Narcissus Bulb Pests of Immersion in Hot Water. Jour. Ec. Ent. **19**: 248-251. 1926.
- (15) —————  
Some Comments on the Treatment of Narcissus Bulbs with Hot Water. Mthly. Bull. Cal. Dept. Agr. **16**: 236-238, April, 1927.
- (16) Dufour, Leon.  
Histoire des Metamorphoses de L' *Eumerus aeneus* Macq. Memoires de la Societe Royale des Sciences De L' Agriculture et les Arts de Lille, pp. 197-200. 1845.
- (17) Felt, E. P.  
27th. Report of the State Entomologist, N. Y., 1911. N. Y. State Ed. Dept., Bull. 510: 119-120. 1912.
- (18) French, G. T.  
Report of Division of Plant Industry: Narcissus Bulb Inspection. Dept. Agr. and Immigration Bull. 233: 19. 1927.
- (19) Fryer, J. C. F.  
Narcissus Flies. Jour. Bd. Agr. London, **21**: 137. 1914.
- (20) —————  
Further Notes on Narcissus Flies. Jour. Bd. Agr. London, **21**: 424-426. 1914.
- (21) Gibson, A.  
The Occurrence of *Eumerus strigatus* Fln. in Canada. Can. Ent. **49**: 190-191. 1917.
- (22) Herold, B.  
Zeitschr. fur Wiss. Insekten. Berlin, Germany, **11**: 345. 1915.
- (23) Hewitt, C. Gordon.  
Report of Dominion Entomologist for the Year Ending March 31, 1911, p. 239.

- (24) Hodson, W. E. H.  
Bionomics of the Lesser Bulb Flies, *Eumerus strigatus* Falln., and *Eumerus tuberculatus* Rond., in South-west England. Bull. Ent. Research, (London) 17: 373-384. 1927.
- (25) Jack, J. G.  
An Enemy of Narcissus and Amaryllis. Garden and Forest, 10: 154-156. 1897.
- (26) Johnson, C. W.  
Some Additions to the Dipteran Fauna of New England. Psyche, 17: 230. 1910.
- (27) MacDougall, R. Stewart.  
The Large Narcissus Fly (*Merodon equestris* Fab.). Jour. Bd. Agr. of London, 20: 594-599. 1913.
- (28) Mackie, D. B.  
Special Regulatory Pest Control. Mthly. Bull. Cal. Dept. Agr. 14: 159-172. 1925.
- (29) Metcalf, C. L.  
*Eumerus strigatus* Again, (Dip. Syrphidae). Ent. News 30: 170-174. 1919.
- (30) Norman, Priestly.  
“*Merodon equestris*” in Southern British Columbia. Proc. Ent. Soc. B. C. 1, N. S., 22-25. 1911.
- (31) Osburn, R. C.  
British Columbia Syrphidae, New Species and Additions to the List. Can. Ent. 40: 10. 1908.
- (32) Packard, A. S.  
Guide to the Study of Insects, 9th. Edition, p. 399 1869.
- (33) Poos, F. W.  
Virginia-Grown Narcissus Bulbs. Florists' Review, 60: 31-33. June 2, 1927.
- (34) Ramsbottom, J. K.  
Contributions from the Wisley Laboratory. XXXI—Experiments on the Control of Eelworm Disease of Narcissus. Jour. Roy. Hort. Soc. 43: 65-78. 1918.
- (35) Reaumur, M.  
Memoires Pour Servir a L'Histoire des Insects. XII. Vol. 4: 499. 1738.

- (36) Riley, Wm. A.  
29th. Ann. Rept. Minn. Agr. Sta.: 1920-1921 Univ. Farm, St. Paul, pp. 55-60. Div. Ent. and Ec. Zool. 1921.
- (37) Schoene, W. J.  
Partial Report of Inspection Work During Autumn of 1919 and Spring of 1920. Qtrly. Bull. Va. State Crop Pest Commission, Blacksburg, II, pt. 2, July 1920, 4 pp.
- (38) Treherne, R. C.  
Report from Vancouver District: Insects Economically Important in the Lower Fraser Valley. Proc. B. C. Ent. Soc. No. 4 N. S. pp 19-33. 1914. Jan. 1914 on p. 31 Narcissus Fly (*Merodon equestris* Fab.)
- (39) Tullgren, Albert.  
Injurious Animals in Sweden During 1912-1916. Meddelande fran Central-anstalten for Jorshruksforsk, No. 152 Entomologiska Avdelningen, No. 27, pp. 104. 1917.
- (40) Van Slogteren, E.  
Weekblad voor Bloembollenculture, Haarleen No. 72. 33: 315. 1923. (Reprint of the same paper for Mar. 23, 1920).
- (41) —————  
Address to the Members of the International Conference of Phytopathology and Economic Entomology, June 28, 1923, at Lisse, Holland. Separate.
- (42) Vassliev, E. M.  
Report on the Work of the Entomological Branch of the Myco-Entomological Ex. Station of the All-Russian Soc. of Sugar-refiners, (in Smiela, Govt. of Kiev) in 1914, Kiev, 1915.
- (43) Verrall, G. H.  
British Flies, 8. No. 34—Genus *Merodon*. pp. 555-560. 1901. No. 1—*M. equestris* Fab. pp. 556-558.
- (44) —————  
British Flies, 8: Genus *Eumerus* pp. 614-622. 1901. *E. strigatus* mentioned as injurious at bottom of p. 615.
- (45) Wahl, B.  
The More Important Animal Pests of our Most Common Vegetables. Mitt. landw- bakter, u. Pflanzenschutzstation, Vienna (n.d.) 70 pp. 1920.

- (46) Weigel, C. A.  
Observations on the Life History of the Narcissus or Daffodil Fly (*Merodon equestris* Fab.). Jour. Ec. Ent. **19**: 497-501. 1926.
- (47) —————  
Paperwhite Narcissi Forced from "Cooked" Bulbs. Florists' Review, Vol. **60**: 25-28, Aug. 4, 1927.
- (48) —————  
Daffodils Forced from Treated Bulbs. Florists' Review, Vol. **60**: 25-57, Sept. 15, 1927.
- (49) Weiss, H. B.  
Additions to Insects of New Jersey. Ent. News **26**: 107. 1915.
- (50) Wilcox, J.  
The Lesser Bulb Fly (*Eumerus strigatus* Fallen) in Oregon. Jour. Ec. Ent. **19**: 762-772. 1926.
- (51) Wilks, Rev. W.  
The Narcissus Fly, *Merodon equestris* Fab. Jour. Biol. Hort. Soc. **26**: 249. 1901.
- (52) Zacher, F.  
The Biology of Pests of Stored Products. Mitt. Biol. Anstalt f. Land- u. Forstwirtschaft, No. 17. 1919.