THE LARGE NARCISSUS FLY, *MERODON EQUESTRIS*, FAB. (SYRPHIDAE).

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(Plate XXXIX.)

Introduction.

Larvae of the Syrphid fly, *Merodon equestris*, known throughout Europe and North America as the Large Narcissus Fly or Large Bulb Fly, attack and destroy narcissi and various other bulbous-rooted plants. A considerable volume of literature has accumulated, more particularly during the past eighteen years, concerning the life-history and control of the pest. A perusal of this literature discloses the existence of numerous discrepancies of opinion amongst authorities on certain fundamental points. For example, some writers maintain that larvae can take two seasons to reach maturity, others definitely state that one year only is required. Again, considerable uncertainty has existed as to the manner in which larvae enter bulbs and dates at which oviposition and pupation are to be expected. Further, more serious from the economic point of view, in spite of the accumulation of literature it can be stated quite definitely that the fly has continued annually to increase in numbers. At the present time commercial growers in Britain are faced with yearly losses of many thousands of pounds worth of valuable bulbs as a direct outcome of fly infestations and it has become increasingly clear that concerted action amongst growers is essential in order that such losses may be diminished.

The writer has been associated for a number of years with the commercial bulb industry and the present publication is the outcome of work and observation extending over eight seasons. The work has been assisted during its latter stages by a Special Research Grant provided by the Ministry of Agriculture and Fisheries.

It is proposed to review in detail the life-history of the fly and to bring forward further evidence concerning the possibilities of obtaining control of the pest under field conditions.

Historical.

The genus *Merodon* is essentially a Southern European one, although a limited number of species occur elsewhere, and the species *M. equestris* is rapidly becoming cosmopolitan. The fly was first recorded in England on 8th June 1869, when Verrall[23] captured a specimen in a south London garden. Verrall noted that the garden had for many years been planted with narcissus bulbs imported from Holland and concluded that the species was imported about that time. By 1896 the fly had become so common that articles commenced to appear concerning the ravages occasioned to narcissus plantations in Cornwall and elsewhere.

Writing in 1914, Fryer[6] stated that the fly occurs in England, Scotland, Wales, and Ireland, and is supposed to have been imported, probably from Holland, but that Theobald considered it native. Theobald based this suggestion on the fact that he had taken the larva in the wild hyacinth, *Scilla nutans*. In the same paper Fryer suggested destroying the larvae by steeping infested bulbs in warm water for from 24 to 48 hours. One year later Fryer[8] improved upon this suggestion and showed that steeping dormant bulbs in water heated to 110°F. for one hour effected a hundred per cent. kill of the larvae, without apparent injury to the bulbs. Fryer carried out further experiments in the following year, but owing to war conditions the results of these were not published and they were subsequently handed to other workers.* The extension of the period of treatment to three hours, largely as a result of Ramsbottom's[17] work, formed the basis of the now universally practised "Hot Water Treatment" of narcissus bulbs as a control for bulb flies, *M. equestris* and *Eumerus* spp., and for bulb eelworm, *Anguillulina dipsaci*.

Some time before 1916 *Merodon equestris* was first observed in the United States of America. Metcalf[16] in that year recorded that adults were taken in some numbers at Bar Harbour, and expressed the fear that the range would continue to extend and that the insect would become a serious pest in the country. Larvae had already been recorded in New Jersey in 1915 by Weiss[21] and in British Columbia and Ontario as early as 1912 by Hewitt[9].

More recently numerous papers dealing with the fly have been published in both Europe and the United States of America. These papers indicate clearly that the pest has rapidly become a very serious menace to commercial stocks of narcissus wherever these are grown. No purpose would be served by mentioning the papers individually here, but reference to the more important of them will be made at relevant points in the present publication.

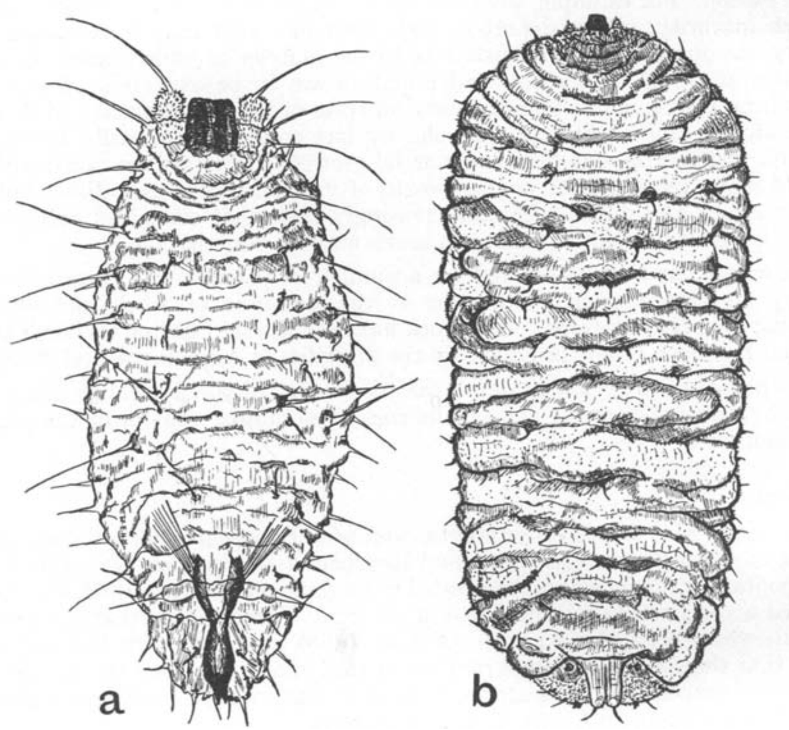

Fig. 1. *Merodon equestris*, F.: *a*, 1st instar larva (× 40); *b*, 4th instar larva (× 6·5).

Description of Stages of Merodon equestris.

Adult (Plate xxxix, figs. 1, 2).

A large conspicuous fly very pubescent and varying greatly in colour. Legs black, hind tibia of male humped inside just after middle and with a conspicuous

* Verbal communication by Mr. J. C. F. Fryer.

process at the tip, hind femora moderately thick. Length 12 mm. (a very full description of the adult fly is given by Verrall[23]).

Ovum (Plate xxxix, fig. 3).

Pearly white, faintly tinged with pink, surface of chorion finely and evenly tessellated. Shape elongate oval, tapering slightly at one end, length 1·6 mm.

Larva (fig. 1).

First instar. Dirty white, elongate oval, truncate posteriorly, posterior spiracular process and mandibular sclerites large and prominent, chestnut-brown in colour. Integument carrying rows of long prominent spinules, longest posteriorly. A prominent anal tubercle on either side of posterior spiracular process, each clothed densely with minute spines and carrying large spinules. Length 1·5–2 mm.

Second instar. Similar, except that the scattered spinules are less numerous and reduced in length to about one-third of those in first instar, and whole integument clothed with minute spinules. Length 2–5 mm.

Third instar. Similar, colour darker, scattered spinules still less prominent, posterior spiracular process relatively smaller. Large spinules on anal tubercles absent. Length 5·5–8·5 mm.

Fourth instar. Almost identical with previous one, except that spinules, anal tubercles, and posterior spiracular process, are again relatively smaller. Length 9·5–19 mm.

Puparium (Plate xxxix, fig. 4).

Tough and leathery, dark brown to black in colour, posterior spiracular process distinct and black, anterior spiracular processes protruded as a pair of horn-like projections on 8th to 10th day after formation. Length 12–14 mm.

Plants attacked.

The following list of bulbous-rooted plants in which *M. equestris* has been found is given by Fryer[6]:—Narcissus, Hyacinth, Tulip (rarely), *Amaryllis*, *Habranthus*, *Vallota*, *Galtonia*, *Scilla*, and *Leucojum*. With regard to attack upon narcissus Fryer presents further information thus, "A leading grower considers that hard bulbs of the *Narcissus maximus* and *N. spurius* type are least attacked, while the most susceptible are *N. poeticus* and *N. leedsii* varieties, and further, varieties with coloured cups are more susceptible than those without." The writer has been unable to obtain confirmation of this suggestion, in fact in the Tamar valley those growers who specialise in the colourless " Double white " frequently find this more seriously damaged than coloured cups such as " Ornatus " and " Horace." The critical factor is almost certainly the ease or difficulty with which the flies can approach the bulbs for oviposition. This in turn is determined largely by the condition of the soil and foliage of any given variety at the time of maximum oviposition and may vary as to variety or varieties from year to year.

After a lapse of 17 years additions to Fryer's list of food-plants are meagre. *Eurycles* can definitely be added, as can *Galanthus*, the wild snowdrop. In this latter plant the writer has found larvae in localities distant from cultivated bulbs of any kind. The attack on *Scilla nutans* recorded by Theobald seems to have been unusual, for many bulbs of this species have been examined, in districts where the fly abounded, without trace of injury being found.

With regard to the tulip it can be stated that oviposition on this plant is not infrequent. Larvae only enter the bulbs with comparative difficulty. Further, the activities of those which successfully effect an entry are likely to lead in a short time to a rapid bacterial and fungous decay of the bulbs. Entire destruction follows, accompanied by premature death of the larvae from starvation. The writer has demonstrated that by periodically moving a larva on into a fresh tulip it can sometimes successfully be brought to maturity. At the same time in no observed case has a larva been found to complete its cycle in the tulip bulb in which it commenced feeding.

Symptoms of Attack.

A clear and detailed indication as to the nature of the injury caused, together with an account of larval behaviour, will be given subsequently. It will perhaps be of some assistance first to review the external symptoms of attack in order that identification of infested bulbs may be the easier, and for our purpose bulbs have been divided into three classes.

Newly lifted bulbs.

In normal commercial practice narcissus bulbs are lifted from the soil in July and early August, at which time the larvae are still small and have caused but little injury. Diagnosis of infested bulbs is therefore not very easy, unless they be submitted to the drastic measure of cutting in half with a knife. Nevertheless, it will be shown that a large percentage of the larvae enter the bulbs through the base plate and many infested bulbs can be detected at this early stage of attack if the base plates be carefully skimmed of all dead tissue with a sharp penknife. If a larva has entered the bulb a small rust-coloured spot, surrounding a tunnel a little smaller than a pin in diameter, is usually discernible in the base plate. Further, if the bulb is of sufficient value to warrant the trouble, judicious cutting and digging into the base with the penknife will frequently kill the larva before it has effected any very material injury.

Bulbs at planting time.

Planting usually takes place in September or early October, some four to six weeks after lifting. By this time the majority of the larvae will have tunnelled the centre of the bulbs to a considerable extent and will have entered their third instar.

With a little experience infested bulbs may usually be detected whilst handling at this stage. Such bulbs are somewhat softer than is normal, particularly in the region of the neck and can be rejected on this score with a very considerable degree of accuracy.

Symptoms in growing bulbs.

Assuming that an infested bulb has remained in the ground, or has inadvertently been planted, one of two things is likely to occur. If the bulb is small it may fail to shoot and be entirely destroyed. On the other hand, if the bulb be moderately large it is rarely killed outright, although the central growing point may be destroyed. Numbers of adventitious buds are likely to be formed in the axils of the individual bud-scales, as a result of the injuries sustained. Each of these buds in due course produces foliage, when, instead of a normal strong shoot appearing above ground, a circle of small leaves, appropriately termed " grass " by commercial growers, is seen. If the damage is a little less severe the infested bulb may itself send up weak, yellowish, and distorted foliage very reminiscent of attack by the bulb eelworm, *Anguillulina dipsaci*.

The above account refers in the main to symptoms of attack upon narcissus, the commercial crop most prone to extensive damage. It may, however, be taken as being generally applicable to attacks upon almost all of the food-plants previously listed.

Biology of the Fly.

Number of generations.

It can be accepted that there is not more than one generation each year, but certain writers have put forward the suggestion that larvae sometimes feed for two seasons before reaching maturity. Bliss[1] goes so far as to say that two forms or species occur, in one of which the larval life is completed in one year, the other having a two-year cycle. Bliss supports this statement by citing experiments in which bulbs were exposed to attack in one year and protected in the following year. In the spring of the third year adult flies emerged from the vicinity of these bulbs. In the writer's experience all larvae, without exception, mature in one year, an experience confirmed by Broadbent[2] working in America. It must therefore be assumed that the protection given by Bliss in the second season was incomplete. Bliss and others have doubtless been confused by the occasional occurrence of quite small larvae in the early months of the year. The presence and history of these will be discussed later.

Occurrence of adult flies.

The period during which adult flies are to be found is a relatively short one. Verrall[23] gives the dates 7th April to 28th June as the extreme limit of occurrence in England, but the April date refers to bred individuals and is therefore of little value. Bliss[1] gives 21st June as the latest date of capture in the field, with the exception of one individual taken on 5th July 1926. Lundbeck[14] gives 28th April to 3rd July as the limit in Denmark. Records kept by the writer for the past seven years provide the following dates of first appearance: 1925, 20th April; 1926, 10th May; 1927, 15th May; 1928, 8th May; 1929, 17th May; 1930, 10th May; 1931, 15th May. Dates of last appearance range from 27th June in 1925, to 9th July in 1931.

One point must be borne in mind, namely, that in forcing houses flies emerge much earlier than is normal. Numbers have been taken as early as 5th February in such situations, whilst one was taken on sallow in the open near Penzance on 18th March 1926. This individual had almost certainly escaped from a forcing house and taken advantage of the suitable weather conditions prevailing at that time. It is most unlikely that such "escapes" would meet with conditions suitable to oviposition so early in the year even if they mated and survived for their maximum life of three weeks.

We can say therefore that the normal flight period in England extends approximately from the first or second week in May until the end of June.

Longevity of adults.

Large numbers of flies have been bred in captivity and confined both in small cages and in insectaries in which they were provided with a close approximation to natural conditions. Females, whether fertilised or not, lived considerably longer than males. The shortest life of a female was 5 and the longest 24 days, the average being 17 days. Males varied from 6 to 18 days and averaged 11 days.

Proportion of sexes.

Many hundreds of flies were bred. Of the total 54·4% were females and 45·6% males. This ratio is of interest in that it agrees exactly with that found previously by Bliss[1] and is remarkable in that Bliss's figure refers to captured flies whilst the writer's concerns bred individuals. It was noted that approximately up to the end of May males were the more numerous sex, whilst during June females became increasingly predominant. This is due to two factors, the relatively earlier emergence of males and the longer life of the females.

Coloration of flies.

The adult flies exhibit striking variation as to colour. Some individuals are almost entirely tawny, some boldly banded with red, orange, and grey, and others entirely black, with the exception of the posterior abdominal segments which may be banded with red, orange, or grey.

Verrall[23] recognises the following varieties :—

equestris. Thorax with grey or tawny pubescence in front, but with a broad black fascia behind ; abdomen all fulvous except about the grey base ; scutellum with black or light pubescence.

narcissi. Thorax with entirely fulvous pubescence ; abdomen grey-haired.

transversalis. All grey-haired, except that the third abdominal segment is black-haired.

validus. Pubescence nearly all black except on the end of the abdomen.

Rondani[18] limits the variety *equestris* to those specimens in which the pubescence on the scutellum is light, placing the dark specimens as var. *bulborum*, which variety has been revived more recently by Bliss.[1]

The writer has collected and bred hundreds of the flies and the sorting of these by means of the varietal characters and the expression of the result in terms of flies per hundred provides the following data :—

TABLE I.

Var. *equestris*	♂ 7%	18%	Var. *transversalis*	♂ 0%	
	♀ 11%			♀ 3%	
Var. *bulborum*	♂ 23%	29%	Var. *validus*	♂ 0%	
	♀ 6%			♀ 14%	
Var. *narcissi*	♂ 16%	35%	Unplaced	♂ 0%	
	♀ 19%			♀ 1%	

In the experience of Bliss[1] and the writer all specimens falling within the var. *validus* are females, and we must therefore conclude that this particular coloration is a sex-linked character. The same appears to hold good for the far less common var. *transversalis*, although a few males placed as var. *narcissi* closely approximate to it. In fact var. *transversalis* is hardly distinct enough to warrant recognition. In the writer's series of flies only 3%, all females, have corresponded exactly with Verrall's description. If we consider the variety a good one, it is essential to erect yet another one into which 5% of flies of both sexes would fall. These flies are distinct from the typical var. *narcissi* in that they bear a definite bright tawny band transversely on the centre of the thorax. With these exceptions, only 1% of all flies cannot be placed in the varieties named above.

At the same time it must be realised that these varieties are purely arbitrary, in that a very considerable range of colouring is covered by each. It would be a simple matter to extend the number appreciably by narrowing the limits of each.

The writer is satisfied that the flies mate irrespective of colour, that the varieties are both cross and self fertile and that the progeny of a particular cross mating show a wide range of coloration. At this the matter must be left for the present, but a careful study of the varieties, conducted on a Mendelian basis, presents a fascinating problem. Such a study would be comparatively simple to carry out, for the flies may be bred with ease under controlled conditions.

Habits of Adult.

The fly is an exceedingly easy insect to rear and breed in confinement. Copulation and oviposition take place quite freely in small cages, provided that there is sufficient light. In this respect *Merodon* differs materially from *Eumerus* spp., in which it is difficult to induce oviposition even in a large insectary.

Emergence from pupa.

Emergence is effected through a large orifice at the anterior end of the pupa. A circular cap, containing on its inner surface the buccal armature of the larva, is broken away, the line of fracture being just behind the points at which the anterior spiracular processes protrude. The fly climbs any prominence near by and very soon becomes fully matured. Ninety per cent. of the flies emerge between the hours of 8 and 10.30 a.m. and none has been observed to emerge after mid-day. In newly emerged females the ovaries are small and the whole abdomen is packed with fatty globules, maturity not being arrived at for several days. Males are sexually mature 24 hours after emergence.

Feeding.

In the field flies may often be taken at flowers. Some preference is shown for those of various members of the order Compositae, notably the common dandelion. Flowering shrubs are visited and also, rather strangely, the large pink flowers of *Mesembryanthemum,* so abundant in the extreme south-western districts.

In captivity the flies thrive upon dilute sugar or honey solutions and also take water freely and frequently. Life is greatly shortened if no liquid be made available.

Response to sunlight and temperature.

One of the strongest arguments in support of the species being of southern origin, rather than indigenous to northern Europe, is the very marked inability to withstand unfavourable weather conditions for any length of time. Britain, Holland, and Denmark probably represent almost the extreme northern limit of the fly. Sweden imports annually large numbers of narcissus bulbs, particularly from Holland, and whilst *Merodon* is frequently bred from such imported bulbs, it does not appear to have become established in outdoor stocks, except perhaps in the extreme south.

The flies are never active on dull days, even if the temperature be as high as 70°F. In bright sunshine they may be quite sluggish at 68°F. if conditions be at all windy. Also there is an invariable tendency for flies to congregate in the warmest and most sheltered spots. Frequently numbers may be seen sunning themselves on convenient tree-trunks, fences, and banks.

Copulation.

This invariably takes place in bright sunshine accompanied by a high temperature. Conditions being suitable, flies of both sexes settle in sunny spots and call one another by means of a high-pitched vibration note which is clearly audible for some considerable distance. The note, which is produced apparently in the thoracic spiracles, is maintained for periods varying from a few seconds to two minutes, and at the conclusion short rapid darting flights are made. The male seizes the female by the thorax whilst in rapid flight and forces her to the ground. He then backs down her body and effects union, meanwhile clasping the thorax with the first pair of legs. The female sits motionless whilst the male, at frequent intervals, rapidly vibrates the wings and abdomen, again emitting the high-pitched call-note. At completion the male falls sideways and almost immediately flies away, the whole procedure occupying from 2–3 minutes.

Males are sexually mature 24 hours after emergence and females rarely copulate until the fourth day after emergence, the most usual day being the 6th or 7th, oviposition commencing 3–6 days later. To take a specific and typical case, a female emerged on 8th June, copulated on 15th June, commenced to oviposit on 21st June and continued daily until death on 30th June.

Oviposition.

Dissections show that each female normally contains from 160 to 200 eggs. In Holland[24] the number laid is given as being from 60 to 100 per fly. It seems very unlikely that such numbers are usually laid by an individual.

In confinement and given every facility no fly has been induced to lay more than 15 eggs in a day or a total number of more than 81 eggs. The average figures obtained from 20 observed females was 5 eggs a day and a total number of 52. The average life of a female fly is 17 days, of which not more than 12 are available for egg-laying, the first 5 being occupied in reaching sexual maturity and mating. Therefore at the maximum rate of 15 eggs a day there is time for 180 to be laid. This figure is arrived at by ignoring entirely the weather factor. In practice, oviposition only takes place under sunny and warm conditions, and in May and June it is most unlikely that more than 2 days in every 3 will be suitable for the operation. This reduces our maximum to one of 120 eggs for an individual fly completing its allotted span. This figure, however, relates to a fly of exceptional performance. If we take the average number produced by the 20 observed females and treat it in a similar manner we find that a figure of the order of 40 eggs only is likely to be expected under normal weather conditions.

Fryer[7] has described the oviposition in some detail, and the writer cannot do better than include a very brief abstract of his observations, which were made on a narcissus bed. "The fly settles repeatedly on the foliage and ground, finally crawling to the centre of a plant. Here not infrequently is a hole ¼ inch or more in diameter left by the dying down of leaves and stem and extending below ground to the bulb itself. The fly backs down the hole and lays an egg on the earth forming the sides of the hole or less frequently on the leaves near the neck of the bulb. If the hole is blocked by earth or leaves the egg may be laid on the earth at the edge of the hole or under lumps of earth lying near. No eggs were found in the foliage above ground."

The writer has had ample opportunity for observing egg-laying, such observations, to a very large extent, bearing out those of Fryer. A point of difference is that eggs have frequently been observed to be deposited actually exposed on the soil surface and on dead leaves above ground. Such eggs rarely hatched, and even when they did so the chance of a larva successfully locating a bulb appeared to be singularly slight. Also, whenever the fly found it possible, eggs were actually tucked between the fractured ends of the outer scales surrounding the bulb neck. A point which Fryer[7] omitted to mention was the manner in which a fly preparing to oviposit extends the ovipositor. This is repeatedly extruded and withdrawn, the sensitive tip seeking actively for a suitable cranny in the soil, or space between the bulb-scales. When such a site is found the fly remains stationary until the egg is laid, a matter of some minutes.

In captivity a fly will lay 15 or 20 eggs on and around one bulb, but in the field one egg to a bulb is the normal procedure, although very occasionally an individual will lay 2, 3, or 4 consecutive eggs on one plant. It is no uncommon thing to find 4 or 5 eggs on one bulb, but almost invariably these have been laid by different flies at different times. Observation was kept on a number of bulbs collected in the field on each of which 3 or 4 eggs had been found. Without exception, eggs on individual bulbs hatched on widely different dates, clearly showing that they were not of the same age.

Egg mortality is high, ranging usually somewhere in the neighbourhood of 30% and rising in periods of adverse weather to nearly 90%. Dry hot weather shrivels up all eggs laid in exposed positions, whilst a spell of a few days of unduly wet conditions destroys nearly all eggs both above and below ground.

Published accounts provide very contradictory evidence as to the duration of the egg stage. In Holland[24] it is stated that the eggs hatch in 1 to 5 days. In the United States of America, Howard[10] gives 3 to 4 days, Weigall[20] 2 to 9 days, Wilcox,[22] in Oregon, 6 to 15 days, and Broadbent[2] states that over 2 years the average duration was 12 to 15 days.

In part these discrepancies may be due to varying climatic conditions, but the shortness of the periods given by some writers strongly suggest that their observations were not commenced upon newly laid eggs. The present writer's observations, carried out on several hundred eggs and extending over 5 years, show marked agreement with those of Broadbent.[2] All viable eggs have been found to hatch between the 10th and 15th day after being laid.

Habits of the Larva.

Entry into bulb.

The larva emerges from the egg through a ragged hole which it bites in the side in close proximity to the smaller end. When newly emerged, as described elsewhere, the larva is markedly dissimilar from the later instars and is exceedingly active. Its first objective is to gain entry into a bulb, and here again some uncertainty has existed as to the exact procedure followed. Weigall[20] states—" a larva was observed to work its way down the side of the bulb and apparently entered it at the base." Wilcox[22] says—" larvae usually enter the bulb through the base plate, this being the only part not protected by several layers of hard tough skin."

The basal region of the bulb is certainly the usual point of entry. A larva hatching from an egg placed near to, or actually upon, the side of the bulb invariably travels to the base plate and enters either at the point where the scale bases meet the base plate or through a depression in the plate itself left by a dead root. Larvae hatching from eggs laid between the scales usually work down between these scales until they reach the base plate, which they then enter through its dorsal surface. Occasionally the scales are too tightly packed together for the larva to progress between them, when entry may be made direct into a fleshy scale in the vicinity of the neck of the bulb.

Larval mortality.

Attention has already been directed to the high rate of mortality amongst the ova. Similarly, mortality of newly emerged larvae is considerable.

Fryer[7] states, " on several occasions 5 eggs were found round one plant and less frequently 3 and 1." This observation is in the experience of the writer accurate. Nevertheless, it is only very rarely that more than one larva is found in a bulb. Migration to a distant bulb of a newly emerged larva can in most cases be ruled out as being most unlikely, and we must therefore assume that, provided that 60% of the eggs hatch, numerous larvae never effect entry into a bulb. Further, up to 20% of bulbs in which entry holes have been made are found to contain minute dead larvae. At the same time, premature death is very rare once a larva has entered a bulb and survived the first few weeks.

Therefore, taking all factors into account, we may expect the progeny of a single female fly to number about twelve at maturity.

Larval behaviour in bulbs.

As we have seen, the newly hatched larva almost invariably enters the base plate of the bulb, either at the side or, more frequently, through the ventral surface. The entry tunnel is so minute that it can only be seen as a small rusty spot. The larva, once ensconced in the bulb, travels slowly through the base plate and for at least the first fortnight remains in this, feeding and growing very slowly and tunnelling usually in a horizontal plane.

At the conclusion of this preliminary period the larva commences to burrow upwards, the burrow usually assuming a rough spiral shape, and, deserting the base plate, enters the upper portion of the bulb. The growing point of the bulb is next devoured and rapid growth of the larva commences, it meanwhile working up through the bulb and forming a tunnel of ever increasing diameter. As the larva expands the tunnel becomes more and more tightly packed with frass, until the air-pocket on which the larva depends for respiration becomes exceedingly small. When matters arrive at this stage the larva descends through the bulb once more and feeds again in the base plate, through which it cuts a shaft of approximately the diameter of a lead pencil. During the later instars of the larval life the posterior spiracular process is actually protruded through this hole at the base of the bulb. The final exit from the bulb is usually made through this same aperture and not often through the neck, as has sometimes been stated, although before making its final exit the larva frequently journeys once more to the upper portions of the bulb for feeding purposes.

Migration from bulb to bulb.

Experimentally it can easily be demonstrated that a partly grown larva has no difficulty in entering a sound bulb. Such entry may be made by the larva cutting directly into the scales in a horizontal plane, or more usually at a point where scales and base plate meet.

In the field such a migration is sometimes necessitated by the larva exhausting entirely the resources of the bulb which it originally entered. This is particularly likely to happen when the attack is upon varieties of narcissus in which the bulb is small, *e.g.*, Ornatus and other Poeticus varieties, or when a larva enters a small offset in larger varieties such as Emperor or Soleil d'Or. Larvae appear unable to find their way to other bulbs through any considerable depth of soil, except by sheer chance, but in an established narcissus bed the bulbs lie closely approximated in clumps, when such migration is easily and not uncommonly effected.

Rate of larval growth.

One of the chief arguments put forward by persons maintaining that larvae may take two years to mature has been the established fact that quite small larvae are sometimes found in bulbs during the late winter and early spring months, it being assumed that such larvae could not reach maturity during the current season.

This assumption is incorrect, as is the somewhat similar one to the effect that flies oviposit on bulbs in store during August, this latter opinion being based upon the not uncommon occurrence of minute larvae in bulbs at planting time in October. Such bulbs have been out of the ground since, say, late July.

It can be stated quite definitely that the rate of growth varies from one individual to another over a very wide range. Accurate records of numbers of larvae have been kept and these provide interesting data.

The following table gives a very fair indication as to the order of variation commonly met with amongst larvae found in commercial samples of bulbs :—

TABLE II.

Year 1929–30	No. of larvae measured	Date measured	Maximum length	Minimum length	Average length
Bulbs lifted and removed to store 4th July, 1929	15	1.8.29	12 mm.	1.5 mm.	4.2 mm.
	20	1.9.29	15 mm.	4·0 mm.	8·6 mm.
	12	12.9.29	16 mm.	4·0 mm.	8·7 mm.
	11	7.10.29	15·2 mm.	3·5 mm.	10·6 mm.
	17	1.11.29	15·6 mm.	8·0 mm.	12·5 mm.
	12	10.2.30	19 mm.	14·0 mm.	16·8 mm.

Concentrating for a moment on comparatively small larvae, it is possible to show in another way the wide variation in the rate at which growth progresses. Numerous batches of bulbs were from time to time exposed to oviposition by *Merodon* flies for periods not exceeding one week in length, and then put aside until it was convenient to examine them. Ignoring completely all unduly large and small larvae and concerning ourselves entirely with larvae 4 mm. in length at the time of examination, we find the following variation in age.

TABLE III.

Batch of bulbs	Possible age of 4 mm. larvae.	
	Minimum	Maximum
A	13 days	15 days
B	18 ,,	27 ,,
C	36 ,,	38 ,,
D	38 ,,	47 ,,
E	44 ,,	53 ,,

We thus see that a larva may take anything from 13 to 53 days to reach a length of 4 mm., and there is no reason to think that these figures represent the limits of possibilities on this score.

As a final illustration, the performance of 3 individual larvae, progeny of 3 eggs laid by one adult on a single day, is of interest.

Each larva originally entered a separate bulb, the 3 bulbs being of one variety and of similar size. The larvae were periodically removed from their bulbs, measured, and returned to fresh bulbs, each thus being afforded equal opportunity of feeding and growth.

TABLE IV.

Eggs laid	Larvae A, B and C hatched and entered bulbs	Date of examination	Age of larvae	Length of larvae		
22.6.30	7.7.30	7.8.30	31 days	A. 6 mm.	B. 8 mm.	C. 4 mm.
		8.9.30	63 ,,	A. 14 mm.	B. 10 mm.	C. 8 mm.
		10.11.30	126 ,,	A. 15 mm.	B. 16 mm.	C. 8 mm.
		10.2.31	218 ,,	A. 17 mm.	B. 19 mm.	C. 14 mm.

Sufficient data have been presented in the tables above to show that larvae of greatly varying size are met with at any given time and that the size of a larva gives little or no indication as to its age. Thus, in Table III, larvae not more than 15 days old and larvae not less than 44 days old all measured 4 mm. in length. Again, in Table IV, one larva reached a length of 14 mm. in 63 days, whilst another was of the same length when 218 days old.

As indicating the extent to which this variation in rate of growth may occur it can be recorded that a single larva, to all appearances perfectly healthy and active, measuring only 5 mm. in length, was found in a bulb on 25th January 1929, the bulb having been in store since the previous August. The larva was transferred to a fresh bulb ; in 27 days its length increased to 8 mm., and a perfect though slightly undersized adult was produced on 6th June. Numerous other, though not quite such extreme, instances could be cited. A tendency has, however, been noticed for larvae whose development has been unduly retarded to be somewhat weakly and to form undersized pupae, from which adults not infrequently fail to emerge.

Reasons for variation in rate of growth.

Let us take first the less extreme variation as shown by the three larvae recorded in Table IV. At first glance the differences between the lengths of the larvae at the time of each examination are rather remarkable. It must be borne in mind that the larval skin is cast at intervals, and that prior to ecdysis growth is slow, whilst immediately after it becomes for a time more rapid. The larval stages of *Merodon equestris* occupy roughly 300 days, and during this period the skin is probably cast four times only. It is therefore only to be expected that a group of larvae hatched at any given time will show some variation, extending even into weeks, as to the date at which ecdysis takes place. The criterion as to the date of ecdysis is the colour of the posterior spiracular process; this is invariably of a light chestnut colour for several days after a moult.

Whilst these observations account satisfactorily for the variation in size of larvae over fairly wide limits, they do not account for the occasional occurrence of small second-instar larvae in late winter and early spring months, and we must look elsewhere for the explanation. Two observations assist us on this score, the first that large fleshy bulbs always contain large, well nourished larvae, and the second that markedly undersized larvae usually occur in partly desiccated bulbs, *i.e.*, bulbs which have been out of the ground for an abnormally long period, or which have been stored under excessively dry conditions. When, as happens very occasionally, such larvae are found in a perfectly normal bulb, they are always in the base plate. Larvae feeding in bulbs kept dry in the laboratory grow more slowly than larvae feeding in bulbs planted in soil in the insectary and, in fact, have sometimes only been kept successfully by the occasional squirting of small quantities of water into their burrow.

With regard to the occurrence of small larvae in the base plates, similar reasons hold good. It has been observed that all larvae grow slowly until such time as they become ensconced in the bulb scales, which they eventually reach by boring through the dorsal surface of the base plate. Sometimes larvae fail to penetrate the scales until long after the normal time for so doing. Again, occasionally the base plate is particularly hard, with resultant unusually slow progress on the part of the larva.

We are thus forced to the conclusion that undue retardation of growth is brought about by a difficulty in obtaining access to the ample supplies of food present in the fleshy scale portion of a narcissus bulb. Definite proof of this is apparently provided by an experiment carried out by the writer in which numbers of newly emerged larvae were fed exclusively on base plates removed from bulbs. These larvae all fed and grew very slowly in spite of ample supplies of fresh base plate tissue being provided. Conversely, larvae fed from the time of hatching on bulb scales alone progressed rapidly.

Departure of larvae from bulbs.

Expressed in round figures a normal larva remains in a bulb for 300 days. Exit from the bulb is usually made through the hole previously cut through the base plate, at least 95% of all larvae leaving the bulb through this hole; approximately 1% emerge through the neck of the bulb and the remaining 4% through some point at the side. In view of the considerable length of the larval life, and the variation in size amongst larvae at any given time during the period, the date of migration from the bulbs is singularly constant and varies very little from season to season. In the extreme south-west of England a few larvae leave in February and the migration commences generally during the first week in March. By mid-March 50% of the larvae have left, and only 3% remain in the bulbs by the end of the first week in April. Full records of dates are not available for other districts, but there are indications that in the eastern counties migration is approximately 14 days later.

Pupal Stage.

Pupation.

Having left the bulb the larva travels slowly through the soil, leaving in its wake a definite tunnel of about the thickness of a lead-pencil. In any but very sandy soils this tunnel can frequently be found and the larva traced to the end of it. The tunnel varies in length from 6 in. to over 2 ft. and terminates usually at surface level, where pupation takes place, with the anterior end of the pupa flush with the soil surface, from 2 to 10 days after the bulb is vacated.

Length of pupal period.

As is the case with many other Syrphid flies, the anterior spiracular processes are not protruded until some time after the pupa is formed. The protrusion usually takes place on the 8th day after pupation, but may be delayed until the 10th day. Broadbent[2] gives 33–61 days as the extreme range of length of the total pupal period. In the writer's experience the length of this stage has shown marked consistency, varying only between 35 and 40 days. At the same time it seems highly probable that it can be prolonged for a further 10 or even 20 days, it being impossible otherwise to account for the total period of time elapsing between the earliest vacation of the bulbs and the appearance of the first flies.

Rate of Increase of the Fly.

In an earlier paragraph it was stated that, at maturity, the progeny of a single fly may be expected to number approximately 12. The figure was arrived at by taking the average performances of some hundreds of flies for several years, the flies being confined under conditions closely approximated to those found in the field.

The determining factor which permits of a material increase in the fly population annually is the abundance and accessibility of suitable material on which to oviposit. Critical field observations have been carried out in Devon and Cornwall on commercial narcissus plantations. Certain of these plantations were newly established in comparatively isolated areas at the time when observations were commenced. The rate of increase in fly populations on such holdings, over a number of years, has shown marked similarity to that rate which has been estimated from the breeding work.

An increase of this order may be expected to continue for a number of consecutive years until the advent of a season markedly adverse to successful oviposition by the fly. Such a season would appear to occur once in every 4 or 5 years and is marked in the year following by a very decided set-back, the population remaining stationary or even showing a slight decline.

Parasites.

One reference to the occurrence of a parasite of *M. equestris* has been met with in the literature, namely that of Cushman,[4] who records *Rhembobius* (*Phygadeuon*) *abdominalis*, Prov., from *M. equestris* in Washington in 1929. In the many hundreds of flies which have emerged in captivity during the present investigation no case of parasitism has been observed. A few undetermined Tachinid flies have appeared amongst flies bred from bulky consignments of infested bulbs. In no case could these be induced to oviposit on or near larvae, and they were very possibly associated with some other insects frequently found in such consignments.

Control Measures.

At the outset it was made clear that, despite the accumulation of a very considerable quantity of literature regarding the fly, progress towards the evolution of a satisfactory and permanent check to its ravages has been in many ways disappointingly slow.

It is clear, from the very nature of the crops attacked and the manner in which attacks take place, that the pest is unlikely to prove an easy one to combat. The position is further complicated by the absolute necessity of taking into consideration other, and equally serious, enemies of bulbous plants which also must be controlled. Again, whilst bulbs in general are tolerant of much during dormancy, it is desirable for their well-being that they are afforded a minimum of disturbance when growing, over periods of time extending into two or more years.

Therefore it is unlikely that any one specific method of control will be applicable in every case. A combination of methods, having due regard for all attendant circumstances, and extending over several seasons, will be most likely to achieve the desired end.

It is proposed to review very briefly the known and accepted control methods already practised and to make further suggestions where possible. The account will conclude with information regarding the use of a poison bait spray against the adult flies, a subject on which a preliminary publication[12] has been made recently.

Cultural methods.

The suggestion that flies might be deterred from egg-laying by a comparatively simple expedient was made as long ago as 1915 by Fryer.[8] This consisted of filling in all holes and crevices present in the soil on beds of bulbs during the period when oviposition was likely to take place. In a more recent publication, concerned primarily with the Lesser Bulb Flies, *Eumerus* spp., the writer[11] paid particular attention to control by means of cultural operations. It was shown that a high measure of success accompanied careful attention to such methods. Indeed so satisfactory are the results obtained by these means that certain of the operations there suggested have become routine measures amongst the more progressive bulb and flower growers.

The measures comprise surface cultivation at the correct season, earthing up and occasionally cutting of foliage, early removal of lifted bulbs to cover, and the use of decoy heaps of valueless bulbs for the attraction of ovipositing flies. Whilst these measures are of undoubted value, factors discussed elsewhere[12] do not permit of their invariably providing an efficient control of the fly when practised alone. It is essential that direct action also be taken against the fly itself, either in the adult or immature stages. Before discussing these, attention must be directed to an additional safeguard which may be practised with benefit in certain cases.

Covering bulbs during growth.

Observation has shown that ovipositing flies are very loath to enter cover, however primitive this may be. It is clearly out of the question to cover large commercial stocks of bulbs whilst in growth, but most large growers possess small beds of bulbs of considerable value. The bulbs may be small stocks of new and rare varieties or material saved for hybridising purposes. Such beds may conveniently and cheaply be covered, during the ovipositing season, by means of horizontal screens of butter muslin or hessian, stretched above the beds at a height of 4 feet from the ground. If the bulb beds are not of greater width than say 5 feet, ample light and air are provided for the plants at the stage of growth normal to the season of the year at which protection is required.

Removal and destruction of infested bulbs.

An account has already been given of the means by which bulbs containing larvae may be detected. We are here concerned with those placed in the last category, namely growing bulbs which in the spring throw up weak or abnormal foliage owing to the presence of a fully developed larva in their centre. Certain commercial growers make a practice annually of sending teams of workers round their beds for the purpose of rogueing out and destroying such obviously affected bulbs. Many larvae are certainly collected in this manner, one grower accounting for over 5,000 in the spring of 1931. Nevertheless in the writer's opinion the procedure is of little or no value on the average bulb farm. Firstly it requires a very keen eye and exact knowledge to detect a reasonably high percentage of such bulbs. Secondly migration of larvae from the bulbs often commences before the symptoms are very obvious, with the result that before the work of rogueing can be anything like completed a high proportion of the bulbs detected and lifted will already have been vacated by the larvae. As against this, on one holding the workers have become so proficient that if the bulb is vacated they search for the larval burrow in the soil and finally, in many cases, collect the pupa.

The writer has a very considerable acquaintance with the field aspect of bulb culture, and it can be stated with confidence that however well such work be done it is unlikely that 50% of the larvae will be accounted for. The remaining 50% are ample in numbers to give rise to an exceedingly severe infestation in the following season.

Swatting of adult flies.

Many growers in the West of England expend much time and energy in destroying adult flies by means of an orthodox fly swat or a home-made apparatus constructed on similar lines with the addition of a long handle. This practice cannot be recommended for two reasons: firstly, the number of flies accounted for is exceedingly small; secondly, indiscriminate swatting usually commences with vigour too early in the year and the "bag" consists very largely, if not entirely, of harmless or beneficial flies, *Eristalis tenax* being the principal victim.

Hot water treatment of bulbs.

The standard hot water treatment of narcissus bulbs is directed primarily against the bulb eelworm, *Anguillulina dipsaci,* and consists of steeping the bulbs whilst dormant in water heated to 110°F. for three hours.

Such treatment is fatal to *Merodon* larvae, as indeed is one hour's immersion at that temperature, but for several very good reasons it is not expedient to treat bulbs in this manner more often than once in every two or three years. After treatment bulbs are usually planted down for two or more years, during which time a very serious reinfestation is liable to occur.

Submersion of infested bulbs in water containing chemicals.

No very promising results have so far attended work on these lines. A varying percentage of larvae can always be killed, even by prolonged immersion in water alone, but the presence of air pockets and the naturally impervious nature of a bulb mitigate against the obtaining of a satisfactorily high rate of mortality, even when using comparatively concentrated solutions of such substances as nicotine or formaldehyde.

Recent experiments, in which air was withdrawn from the bulbs during immersion in the above liquids, by means of a partial vacuum, have shown more promise of success. It is proposed to continue work on these lines with the view principally of endeavouring to obtain a substitute for the not entirely satisfactory hot-water treatment.

Fumigation of bulbs.

(*a*) Paradichlorbenzene.

As previously described[11] box fumigation of dormant bulbs with this material affords a complete control for bulb fly larvae. It is a method worthy of more extended use than it is given at present, for it is entirely non-injurious to the bulbs. Provided that a suitable chamber is constructed, bulbs may be placed directly in this in their storage trays, thus avoiding additional handling. 4 oz. of paradichlorbenzene should be used for every cubic foot of space in the container, as originally suggested by Stenton,[19] and the fumigation should be of 120 hours duration. The initial cost of paradichlorbenzene is considerable, but the original charge will remain effective for a large number of batches of bulbs, and in fact will require but small additions during the treating season, provided that reasonable care is taken in keeping the chamber closed except when filling and removing bulbs. The only point to which very special attention should be paid is to ensure that the bulbs are not permitted to heat or sweat during fumigation. The danger of this occurring is almost entirely obviated if care is taken that the bulbs are dry when placed in the chamber.

(*b*) Carbon disulphide.

Fumigation of dormant bulbs with this substance has been carried out in the United States. Mackie[15] in 1922 killed all Lesser Bulb Fly larvae and therefore presumably *Merodon,* which is less resistant, by vacuum fumigation, 2 lb. carbon disulphide per 100 cubic feet for a period of one hour having been used. Mackie reported that bulbs were uninjured by the treatment, but that longer exposure usually resulted in damage. That the method cannot be considered very successful may be judged from the subsequent U.S. Quarantine order in which fumigation of bulbs with calcium cyanide was officially authorised.

(*c*) Calcium cyanide.

Some years ago the writer carried out a few preliminary tests of this fumigant. The experiments were not very extensive but sufficient evidence was obtained to state that, with care, bulb fly larvae may be killed without injury to the bulb. It was not found possible to devise a dose lethal to bulb eelworm without at the same time injuring the bulb. Doucette[5] in 1924 carried out experiments with calcium cyanide fumigation of bulbs, being concerned first with aphides occurring on Iris in store and extending the work to include *Merodon* larvae in Narcissus in 1926. Cole[3] carried on the work and now definitely recommends fumigation on the lines suggested in the U.S. Quarantine order as being reasonably satisfactory. Bulbs should be fumigated in an air-tight box at a temperature between 60 and 90°F. The dosage being 12 oz. of calcium cyanide (granular) per 100 cubic feet of space and the exposure 4 hours. It is not yet certain whether such fumigation will kill all first instar *Merodon* larvae.

Deterrents to oviposition.

As already recorded[12] no great success has attended the use of deterrent material for the purpose of keeping flies away from beds during the oviposition season. Such substances as paraffin emulsion sprays or broadcast dressings of naphthalene have been used.

Further field trials with naphthalene and proprietary soil fumigants have been carried out in various parts of the country during the past season. These have, with a few exceptions, furnished further proof that such methods are usually too transitory in their action to afford any material benefit. It must, however, be recorded that in one instance repeated surface dressings of crude naphthalene, each dressing consisting of 3 cwt. an acre, appeared to effect a very satisfactory measure of relief from infestation.

Poison-bait sprays.

The suggestion that a poison-bait spray might possibly afford a means of destroying the adult flies emanated originally from Holland.[24] It was, however, a suggestion only and no trials appear to have been carried out there with a view to testing its efficacy.

The writer first commenced field experiments with poison baits in 1926, as an outcome of the observation that in captivity the flies fed freely upon solutions of sugar in water. A preliminary publication, recording the results obtained up to 1930 was published recently,[12] and there is no need to recapitulate the evidence then set out. Sufficient to say that two sprays were tentatively put forward as showing promise of success. Subsequent work has shown that one of them, comprising a mixture of sodium arsenite, sugar, glycerine, and water, proved its superiority and has now been adopted definitely.

The preliminary publication referred to above was concerned largely with comparatively small scale work. During the past season trials have been conducted on a more extensive basis, and the bait used throughout the trials was standardised, being composed as follows :—

Material	Cost
	s. d.
Sodium arsenite 4 oz.	0 5
Glycerine (crude) 1 lb.	0 8
Sugar (white cane) 2 lb.	0 5
Water 4 gall.	—
	1 6

The bait was applied by means of standard knapsack sprayers of various well-known makes, applications being made, as far as possible, weekly throughout the ovipositing season. In the year under consideration this lasted roughly from 20th May to 1st July.

It will be appreciated that a critical examination of results obtained from such trials is difficult if not impossible to make. At the same time some 200 acres of growing bulbs were treated. Definite information was obtained as to the practicability of the procedure and cost involved. Bulbs were examined on subsequently lifting them and every indication of a diminution in degree of infestation was obtained. For convenience the trials will be discussed in three sections.

(*a*) A baiting scheme inaugurated at the Western Commercial Show, Penzance, in March 1931.

This scheme was financed from the Show Funds, growers participating in the scheme agreeing to pay 5s. an acre of bulbs baited, the work being carried out by officials of the Cornwall County Council. Some 70 acres in the vicinity of Penzance were baited under this scheme.

The work was thoroughly carried out and records show that an average quantity of 6 gallons of spray fluid was used to an acre. Including time occupied in mixing the ingredients, the average rate of spraying was one acre an hour. The final figure arrived at, estimating wages at 1s. an hour and allowing 3d. an acre for the loan of the spraying machines gives a cost of 3s. 6d. an acre for a single spraying or 17s. 6d. an acre for the 5 sprayings considered needful during the season. This figure is ridiculously low when one considers the large capital sum represented by the value of 1 acre of bulbs of even the commonest of commercial varieties.

The writer is indebted to Mr. Abbiss, Horticultural Superintendent for Cornwall, for the following information as to the result of these trials :—

"Numbers of dead flies were found after treatment and there appeared to be a decrease in grub injury in the treated areas. The fact that some growers outside the areas, who did not bait, have had a very bad infestation and lost quantities of their bulbs seems to emphasise the value of the treatment."

(*b*) Baiting by individual growers in the West of England.

About 100 acres were treated in places throughout Cornwall and at least one centre in Devon. In these cases it has not proved possible to obtain accurate figures as to the cost of the operations, principally owing to the writer's removal from the West of England. At the same time numbers of these growers have expressed satisfaction as to the results obtained, as judged by the condition of bulbs lifted and examined subsequently, and have signified their intention of repeating the baiting annually.

(*c*) Baiting carried out by a grower of comparatively valuable stocks of bulbs in S.E. England.

An account of this work must be included as it is in very marked contrast with the methods adopted in the other instances.

As a commencement, very careful attention was paid to the response to weather conditions exhibited by *Merodon*, and spraying was only carried out between 10 a.m. and 3.30 p.m. on warm and sunny days. Again, the first spraying was followed immediately by a second on account of a very heavy thunderstorm intervening, which entirely washed away the first application. Seven complete and a partial eighth spraying were made instead of the five recommended, the first commencing on 26th May and the last concluding on 7th July.

A one gallon Holder-Harriden Sprayer was used. It was found that only one acre a day of $5\frac{1}{2}$ hours was covered in a manner satisfactory to the grower, as opposed to one acre an hour in previous cases. Again, an average of 16 gallons an acre of fluid was used instead of the 6 gallons previously or the 8 gallons originally suggested by the writer. The grower in question maintains that the extra cost per acre involved is negligible when considering the value of the crop and rightly states that it is impossible to wet all foliage with a smaller quantity of fluid.

As regards the result obtained at this centre, again exact figures are unobtainable, but the grower reports " This lifting season has been definitely noticeable for apparent lack of *Merodon* infested bulbs."

Discussion of results.

Sufficient evidence has been produced to indicate that poison-bait spraying of bulbs is not an excessively costly procedure and that such spraying appears to produce a marked diminution of bulb fly attack. It further shows that the number of sprayings and rate of application has not been entirely standardised.

In the opinion of the writer, 6 gallons an acre is a distinctly low rate to work on, although it must be realised that no effort need be made to cover every portion of foliage. The object in view is to obtain a wide distribution of the bait in order that flies are likely to find it by chance when alighting. In the case of growers of smaller quantities of highly valuable stocks the use of 16 gallons an acre, with an increased number of applications is probably economically sound. For the general bulb farmer it is recommended that the 6 gallon rate used in 1931 be increased to the 8 gallons originally recommended, or even to 10 gallons an acre.

In the opinion of the writer the use of a poison-bait spray containing sodium arsenite against *Merodon equestris* will provide a high measure of control. At the same time until further evidence be forthcoming it would be unwise to consider it sufficiently effective unless used in combination with control methods previously advocated.

Methods recommended for obtaining control of the fly.

1. Bulbs should be subjected to the " hot water treatment " whenever they are lifted. In practice this will be every second or third year and will ensure complete freedom from infestation in newly planted stocks.

2. In the subsequent season or seasons when the bulbs remain in the ground special attention should be paid to surface cultivation of the soil during the whole of the period during which ovipositing flies are likely to be present.

3. Periodic spraying with the poison-bait spray should be resorted to, whether the bulbs be due for lifting or not. Sprayings should be made at approximately weekly intervals, the exact dates being determined by the weather conditions prevailing.

The sprayings should commence and terminate at approximately the times previously mentioned, *viz.*, the second week in May and the last week in June, or first week in July.

4. In certain cases, *e.g.*, where lifted bulbs are to be forced and are known to be free from bulb eelworm, fumigation might perhaps with advantage be substituted for the hot water treatment.

Summary.

1. The history of the occurrence of *Merodon equestris* in various countries is related and a list of known food-plants given.

2. The immature stages of the fly are described in detail.

3. The biology of the fly is fully discussed and additions made to our knowledge regarding it.

4. Control measures are reviewed and additional information is given, particularly with reference to the use of a poison-bait spray against the adult flies.

5. Recommendations are made as to the most satisfactory combination of methods to use for the purpose of obtaining control of the fly under field conditions.

6. A list of literature cited is given.

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Fig. 1. *Merodon equestris*, adult male, x 4.

Fig. 3. *Merodon equestris*, ova on leaf, x 2·8.

Fig. 2. *Merodon equestris*, adult female, x 4.

Fig. 4. *Merodon equestris*, puparium, x 3·8.

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