THE ROOT MAGGOT COMPLEX (DIPTERA: ANTHOMYIIDAE) IN CRUCIFEROUS CROPS OF THE PACIFIC NORTHWEST

by

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THE ROOT MAGGOT COMPLEX (DIPTERA: ANTHOMYIIDAE)
IN CRUCIFEROUS CROPS OF THE PACIFIC NORTHWEST

INTRODUCTION

Root inhabiting maggots (Diptera: Anthomyiidae) have long been recognized as the most injurious pests of cruciferous crops in northern Europe, the northern United States, and Canada. Formerly economic entomologists have often considered any maggots found on cruciferous crops as being the cabbage maggot, Hylemya brassicae (Bouché) but it is now known that several species occur separately or in mixed populations on these crops. Furthermore, these populations vary seasonally and geographically and each species differs in habit, life history, and economic importance. It thus becomes important to be able to distinguish the various species and to know which ones occur on any given crop.

Next, in any control tests involving root maggots, it is essential to know the habits and life histories of each of the pest species involved. Only then can the economical and effective use of insecticides be expected.

In line with these requirements, the present paper gives a key, drawn from several sources, to separate the root maggot species commonly found on cruciferous crops of the Pacific northwest. It then presents an analysis of field populations as shown by root maggot collections from various crucifers in several locations in the Pacific northwest and proceeds to a discussion of the life histories and habits of each of the species.

SYSTEMATIC POSITION OF THE ROOT MAGGOTS

Williston (42, pp.331-336) includes the root maggots in the family Anthomyidae. Comstock (7, p.786) also includes them in the family Anthomyiidae, which he places in the superfamily Anthomyioidea, and while Essig (9, p.796) includes them in the same family, he places the family in the superfamily Muscoidea. Essig states, however, that the status of the Anthomyiidae and related families is quite uncertain, no two students of the Diptera agreeing on their position. Curran (8, p.393) includes the root maggots in the family Muscidae. The Muscidae of Curran includes the Scatophagidae, Anthomyidae, and those Muscidae (of the Williston manual) without hypopleural bristles. Curran (8, pp.384-385) justifies this arrangement by saying:

> There is no means by which the Scatophagidae can be separated from the Anthomyidae, unless the size of the lower lobe of the squamae is used, in which case the genus Anthomyia must be associated with the Scatophagids while many of the other genera would form a different family. Wing venation is not a character to be used in separating families in this group, nor can the character of the plumosity of the arista be used.

The Anthomyiidae was originally included with the Muscidae from which it was separated by Meigen in 1838.

In view of the uncertainty of the classification, it seems simplest for the purposes of this paper to follow Williston, Comstock, Essig, and others in considering the Anthomyiidae as a family closely allied to the Muscidae but structurally distinct from it.

Unfortunately, there is also considerable uncertainty regarding the generic and specific designations of the root maggots. The names adopted in this paper are those which are currently most generally accepted: Hylemya brassicae (Bouché) for the cabbage maggot, H. floralis (Fallen) for the turnip maggot, H. cilicrura (Rondani) for the seed-corn maggot, and H. fugax (Meigen).

H. brassicae has been recorded in the literature under several names including Anthomyia brassicae Bouché, Anthomyia floralis Fallen, Chortophila floccosa Macq., Aricia floralis Meig. non Fallen, Anthomyia raphani Harris, Anthomyia radicum L., Phorbia floralis, Phorbia brassicae, Pegomyia brassicae, Phorbia floccosa, Chortophila brassicae, and Erioischia brassicae. The somewhat complex synonymy of this species has been dealt with by Schoene (30, pp.103-104) and by Huckett (11, p.24).

H. cilicrura has been discussed in the economic literature under the names Phorbia fusciceps Zett., Anthomyia zeae Riley, Pegomyia fusciceps Zett., Chortophila fusciceps Zett., Hylemyia deceptiva Fitch, Anthomyia augustifrons Meigen, Chortophila cilicrura Rond., Phorbia cilicrura Rond., Anthomyia radicum var. calopteni Riley, Delia cilicrura Rond., and Hylemya cana Macq. (26, p.2). The synonymy has been given by Huckett (11, p.24).

H. floralis (Fall.) has been referred to as Phorbia floralis Fallen and Hylemya crucifera Huckett while Miles has published on H. fugax (Meigen) as Pegohylemyia fugax (Mg.)

Further, the name Hylemya Robineau-Desvoidy was amended to Hylemyia by Macquart in 1835 but the former has precedence (9, p.796).

LOCALE OF STUDIES AND METHODS

Most of the observations reported here were made on Vancouver Island at Victoria, Courtenay, and Alberni, but data were also obtained from Agassiz, B.C., Puyallup, Wash., and several localities in Oregon.

In order to determine species occurrence and the role played by each, a study was made of maggot collections obtained from cruciferous crops in each of several localities. To determine population trends and ecological successions in the case of rutabagas, periodic collections were made at intervals from the same field throughout a growing season. This was done at Victoria in 1952, 1953, and 1954; at Courtenay in 1950, 1951, 1952, 1953, and 1954; and at Alberni in 1950 and 1951.

The maggots found were removed from the roots and usually preserved directly in 70 per cent ethyl alcohol. It was found, however, that better specimens were obtained if the live maggots were dropped into hot water (180-200° F.), left there for five minutes, or until the water cooled, and then placed in 80 per cent ethyl alcohol. This latter method gave nicely distended, clear white maggots. Maggots dropped directly into alcohol tended to darken after a few months.

Determination of the maggots was done by the writer using the key worked out by Brooks (3, pp.114-116). Some of the initial determinations were checked by Mr. Brooks himself. A binocular microscope with magnifications of 20x and 60x was used to make the identifications. A compound microscope was necessary to study the detailed structure of the cephalo-pharyngeal skeleton and anterior and posterior spiracles. Partial clearing in 10 per cent potassium hydroxide was required to allow adequate observation of the cephalo-pharyngeal skeleton.

Whenever slides were necessary, euparal was used as the mounting medium. This material clears and mounts from 95 per cent alcohol.

Oviposition data for Hylemya brassicae (Bouché) were obtained at Victoria in 1952 and 1953 by making twice weekly counts of the eggs laid around 10 marked plants. All eggs were removed with a camel hair brush at each counting. Egg laying on cabbage and rutabagas was determined in this manner.

Direct field observations were emphasized wherever possible. Observations were specifically directed to learn of:

1. Adult habits
2. Adult abundance and activity in relation to seasonal and variable fluctuations of weather factors
3. Effects of soil moisture on root maggot populations
4. Factors involved in the biological control of root maggots

KEY TO THE HYLEMYA SPECIES ATTACKING CRUCIFEROUS CROPS IN THE PACIFIC NORTHWEST

The following keys have been modified after Brooks (3, pp.112-116) with additions from Miles (21, pp.83-90). Most features utilized in these keys are illustrated in Plates I-IV.

Key to the eggs.

1. Dorsal chorion with a reticulated pattern 2
   Dorsal chorion ridged 3

2. Ventral surface with a groove along the entire length .... H. fugax (Meigen)
   Ventral surface with a shallow groove on the anterior third only .... H. cilicrura (Rondani)

3. Length from 0.9 to 0.95 mm. ..... H. brassicae (Bouché)
   Distinctly larger; length from 1.1 to 1.2 mm. .... H. floralis (Fallen)

Key to the third instar larvae.

1. Cuticle covered with transparent spines; tubercle "x" (median posterior) large and bifid .... H. fugax (Meigen)
   Cuticle without spines; tubercles "x" small and separate, or absent 2

2. Slit in the upper wing of the pharyngeal sclerite short and wide; anterior spiracles with 6 to 8 divisions; posterior spiracular plate without a button .... H. cilicrura (Rondani)
   Slit in the upper wing of the pharyngeal sclerite long and slender; anterior spiracles with 8 to 12 divisions; posterior spiracular plate with a button ... 3

3. Tubercle "a" divided, the inner division being smaller and appearing as a separate tubercle .... H. floralis (Fallen)
   Tubercle "a" bifid at the apex .... H. brassicae (Bouché)

Key to the adults.

1. Anterior postsutural supraalar bristle (prealar) more than half as long as the following bristle 2
   Anterior postsutural supraalar bristle short and fine, less than half as long as the following bristle ... 5

2. Males (holoptic) 3
   Females (dichoptic) 4

3. Hind femur very hairy on the basal half of the anterior surface; hind femur with 3 or 4 bristles in a short row on the apical third of the anteroventral surface .... <u>H. brassicae</u> (Bouché)
   Hind femur not very hairy; anteroventral row of bristles longer and with stronger bristles .... <u>H. floralis</u> (Fallen)

4. Middle femur with a strong anteroventral bristle near the base, the ventral bristles strong; front femur with 3 to 6 small, erect bristles on the anterior surface; front tibia with 2 posterior bristles .... <u>H. brassicae</u> (Bouché)
   Middle femur without an anteroventral bristle, or this very weak, the ventral bristles weak; front femur usually without erect bristles on the anterior surface .... <u>H. floralis</u> (Fallen)

5. Males (holoptic) 6
   Females (dichoptic) 7

6. Hind tibia with a comb-like series of erect, bristle-like hairs along the entire length of the posteroventral surface .... <u>H. cilicrura</u> (Rondani)
   Hind tibia without a complete series of erect hairs along the posteroventral surface; abdomen broad and flattened, with greenish-grey pollen; arista noticeably haired .... <u>H. fugax</u> (Meigen)

7. Arista noticeably haired; abdomen subshining, greenish with only thin pollen .... <u>H. fugax</u> (Meigen)
   Arista not noticeably haired; abdomen grey or yellowish-grey with a darker central line dorsally .... <u>H. cilicrura</u> (Rondani)

SPECIES OF ROOT MAGGOTS
COLLECTED IN THE PACIFIC NORTHWEST

Brooks (3, p.110) records nearly 30 species of Diptera that have been collected from the roots of cruciferous plants in Canada since 1946. He points out, however, that the presence of maggots in a damaged root does not necessarily mean that those particular maggots are responsible for the damage--they may be present only as a result of the damage. The root may be damaged by primary phytophagous species, by disease, or by mechanical injury. Whatever its cause, this damage subsequently attracts phytosaprophagous species and, as the decay progresses, additional saprophagous species, predators, and parasites are attracted to the root.

Brooks' list of Diptera which have been collected from the roots of cruciferous plants in Canada is given below. It is arranged in order of ecological succession.

Group I. Phytophagous species causing extensive root damage.

Hylemya brassicae (Bouché) (Anthomyiidae)
Hylemya floralis (Fall.) (Anthomyiidae)
Hylemya planipalpis (Stein) (Anthomyiidae)

Group II. Phytophagous or saprophagous species that may cause root damage under certain conditions but that are generally present only with members of Group I and in small numbers, occasionally being zoophagous.

Hylemya cilicrura (Rond.) (Anthomyiidae)
Hylemya trichodactyla (Rond.) (Anthomyiidae)
Hylemya fugax (Mg.) (Anthomyiidae)
Muscina assimilis (Fall.) (Muscidae)
Muscina stabulans (Fall.) (Muscidae)

Group III. Phytosaprophagous species that extend the damage caused by members of Groups I and II or by disease or mechanical injury.

Paragopsis strigatus (Fall.) (Syrphidae)

Group IV. Phytosaprophagous or zoosaprophagous species.

Sciara sp(p). (Sciaridae)
Cecidomyid species
Oscinella coxendix (Fitch) (Oscinidae)
Leptocera sp. (Borboridae)
Allophyla sp. (Helomyzidae)
Lonchaea flavidipennis (Zett.) (Lonchaeidae)
Phorid species
Fannia canicularis (L.) (Anthomyiidae)
Fannia scalaris (F.) (Anthomyiidae)
Musca domestica L. (Muscidae)
Phaenicia sericata (Mg.) (Calliphoridae)
Calliphora vicina Desv. (Calliphoridae)
Sarcophaga sp. (Sarcophagidae)

Group V. Zoophagous species.

Psilocephala aldrichii Coq. (Therevidae)
Thereva duplicis Coq. (Therevidae)
Asilus sp. (Asilidae)
Platypalpus aequalis Lw. (Empidae)
Dolichopus spp. (Dolichopodidae)
Phaonia sp. (Anthomyiidae)

This arrangement should be kept in mind in interpreting the data given hereafter.

Representative results of root maggot collections from cruciferous crops in the Pacific northwest are given in Tables 1-4. The results of the "periodic" maggot collections from rutabagas in several localities on Vancouver Island are given in Tables 1, 2, and 3, and results of root maggot collections from Oregon are presented in Table 4. Other results will be given in the text.

At Courtenay, B.C., *Hylemya brassicae* (Bouché) made up the bulk of the root maggots collected from rutabagas during 1950, 1952, and 1954. *H. floralis* (Fallen), however, formed a significant part of the August and

Table 1. Number of _Hylemya_ larvae and percentage of the various species collected from rutabagas grown at Courtenay, B.C. (Avent farm)

Date		No. of larvae	PERCENTAGE		
			brassicae	floralis	cilicrura
1950					
Aug.	17	46	69.6	26.1	4.3
Aug.	31	86	64.0	33.7	2.3
Sept.	20	44	63.6	6.8	29.6
Nov.	3	4	100.0	0.0	0.0
1951					
July	17	0	-	-	-
Aug.	3	9	100.0	0.0	0.0
Aug.	16	11	81.8	0.0	18.2
Aug.	29	26	34.6	61.5	3.9
Sept.	17	22	0.0	100.0	0.0
Oct.	2	2	100.0	0.0	0.0
1952					
July	14	0	-	-	-
Aug.	8	9	88.9	11.1	0.0
Aug.	20	14	71.4	28.6	0.0
Sept.	12	3	66.7	0.0	33.3
Oct.	20	3	100.0	0.0	0.0
Nov.	10	16	100.0	0.0	0.0
1953					
Aug.	14	72	29.2	25.0	45.8
Oct.	3	23	82.6	0.0	17.4
Nov.	3	27	96.3	0.0	3.7
1954					
Aug.	2	7	71.4	0.0	28.6
Aug.	24	64	98.4	0.0	1.6
Oct.	5	87	100.0	0.0	0.0

Table 2. Number of *Hylemya* larvae and percentage of the various species collected from rutabagas grown at Alberni, B.C. (Chase farm)

Date	No. of larvae	PERCENTAGE	
		brassicae	cilicrura
1950			
Aug. 1	46	76.1	23.9
Sept. 1	24	100.0	0.0
Oct. 2	36	97.2	2.8
Nov. 3	23	100.0	0.0
1951			
June 28	3	100.0	0.0
July 17	13	76.9	23.1
Aug. 2	76	81.6	18.4
Aug. 16	52	86.5	13.5
Aug. 30	12	83.3	16.7
Sept.18	32	100.0	0.0
Oct. 3	34	97.1	2.9
Oct. 21	44	36.4	63.6

Table 3. Number of *Hylemya* larvae and percentage of the various species collected from rutabagas grown at Victoria, B.C. (Mattick farm)

Date	No. of larvae	PERCENTAGE		
		brassicae	cilicrura	fugax
1952				
July 16	3	100.0	0.0	0.0
July 28	13	69.2	30.8	0.0
Aug. 11	31	77.4	22.6	0.0
Aug. 18	20	35.0	65.0	0.0
Sept. 3	68	51.5	48.5	0.0
Sept.25	54	18.5	81.5	0.0
Oct. 28	187	46.0	53.5	0.5
1953				
Aug. 12	19	68.4	31.6	0.0
Oct. 28	39	100.0	0.0	0.0
1954				
Sept. 2	13	84.6	15.4	0.0
Sept.27	19	94.7	5.3	0.0
Oct. 27	49	91.8	6.1	2.1

Table 4. Number of *Hylemya* larvae and percentage of the various species collected from crucifers in Oregon.

Date	Location	Host	No. of larvae	PERCENTAGE *brassicae*	*cilicrura*	*fugax*
May 5,1953	Gresham	wild mustard	69	94.2	5.8	0.0
May 15,1954	Corvallis	wild mustard	127	100.0	0.0	0.0
May 20,1954	Sandy	cabbage	21	95.2	4.8	0.0
May 21,1954	Lake Labish	charlock	46	97.8	2.2	0.0
May 28,1954	Lake Labish	wild radish	10	100.0	0.0	0.0
June 18,1953	Santa Clara	wild mustard	17	100.0	0.0	0.0
July 2,1953	Corvallis	radish	6	100.0	0.0	0.0
July 9,1947	Corvallis	turnip	53	86.8	13.2	0.0
July 23,1953	Corvallis	radish	34	100.0	0.0	0.0
July 23,1953	Corvallis	wild mustard	45	93.3	6.7	0.0
July 23,1953	Corvallis	turnip	40	95.0	5.0	0.0
July 25,1953	Corvallis	radish	26	96.2	3,8	0.0
Aug. 27,1953	Fairview	wild mustard	48	91.7	8.3	0.0
Sep. 14,1953	Corvallis	wild mustard	141	90.1	9.9	0.0
Sep. 16,1953	Corvallis	turnip	196	100.0	0.0	0.0
Oct. 3,1953	Corvallis	turnip	80	100.0	0.0	0.0
Oct. 7,1954	Corvallis	turnip	139	88.5	11.5	0.0
Oct. 15,1953	Corvallis	turnip	21	100.0	0.0	0.0
Nov. 19,1953	Portland	cauliflower heads	19	0.0	0.0	100.0
Nov. 27,1953	Portland	wild mustard	14	100.0	0.0	0.0
Nov. 27,1953	Portland	cauliflower heads	16	6.3	0.0	93.7

September collections of 1950 and of the August collections of 1952 and 1953; it was the predominant species during the latter part of August and greater part of September of 1951. H. cilicrura (Rondani) was present in fair numbers on September 20, 1950, and on August 14, 1953, but was found only in small numbers during 1951 and 1952.

At Alberni, B.C., H. brassicae was the primary species on rutabagas throughout both 1950 and 1951. H. cilicrura occurred in the August 1 collection and, to a lesser extent, in the October 2 collection of 1950 and was fairly abundant during August and the latter part of October, 1951.

At Victoria, B.C., during 1952, H. brassicae was the important species. H. cilicrura, however, was very abundant, especially after mid-August. A single specimen of H. fugax (Meigen) was taken on October 28. The 1953 and 1954 collections were largely H. brassicae with some H. cilicrura. One H. fugax larva occurred in the October 27, 1954, collection.

Collections from rutabagas at Smithers and Prince George in August, 1954, were predominantly H. floralis but a collection from one of the same rutabaga crops at Smithers in early November consisted of H. brassicae larvae.

Several other species of maggots have been collected in small numbers from rutabagas in B.C. They include *Muscina assimilis* (Fall.) (Muscidae), *Paragopsis strigatus* (Fall.) (Syrphidae), *Sciara* sp. (Sciaridae), *Sarcophaga* sp. and a species of Therevid, probably *Thereva* sp. The status of each of these may be determined by reference to the list given on pages 9-10.

Numerous maggot collections from cabbage and cauliflower on Vancouver Island were examined and found to consist largely of *H. brassicae*. Small numbers of *Fannia canicularis* (L.) and *H. cilicrura* also occurred. *Muscina assimilis* was abundant on the roots of cabbages affected by club root which had begun to decay.

A single collection of root maggots from broccoli at Prince George, B.C. (August 25, 1954) consisted of 23 *H. floralis* and 1 *H. cilicrura*.

Three collections made from turnips at Puyallup, Washington, in 1952, were examined by the writer. Larvae collected in July were: *H. brassicae* 8, *H. cilicrura* 3, and *Muscina* sp. 2. Sixty-one larvae collected on October 25 were all *H. brassicae* and those collected on November 19 were: *H. brassicae* 140, and *H. fugax* 2. Stitt has published these results (34, p.963).

Root maggot collections from Oregon show that *H. brassicae* is the predominant species, at least in the areas represented in the collections. Small numbers of

H. cilicrura were also present and *H. fugax* occurred on cauliflower heads at Portland in November, 1953.

Thus, *H. brassicae* and *H. cilicrura* are the most generally distributed and commonest root maggots of crucifers in British Columbia, Washington, and Oregon. *H. floralis* occurs in some areas of B.C., e.g., Courtenay and Smithers, along with *H. brassicae*. *H. fugax* was collected in small numbers at Victoria, B.C., Puyallup, Wash., and Portland, Ore.

THE CABBAGE ROOT MAGGOT, *HYLEMYA BRASSICAE* (BOUCHÉ)

Status

Literature synopsis

The cabbage root maggot has been known in continental Europe since it was described by Bouché in 1833 and its damage to cruciferous crops early received much attention from the economic entomologists of Norway, Sweden, and Finland. In England the pest was mentioned as early as 1829 and Miles (20, p.234) states that the cabbage root maggot is the most numerous and injurious species of root maggot over most of Britain. The insect was first recorded in the United States in Massachusetts in 1835 by Harris and since then has been recorded in destructive numbers in most of the northern states. It is not known when this pest reached Canada but it was mentioned by Fletcher in his annual reports almost every year from 1885 to 1906. Brooks (3, p.116) states that "this species is the major pest of radish, turnip, cabbage, and other cruciferous garden crops in British Columbia and from Ontario to Newfoundland".

Slingerland (31) was apparently the first in North America to publish a fairly comprehensive account on the biology of H. brassicae. This work was followed by that of Smith and Dickerson (32) of New Jersey and by Schoene (27, 29, and 30) of New York. More recently Whitcomb (41) has given an account of H. brassicae in Massachusetts.

Canadian work on root maggots (and particularly on H. brassicae) has followed the lead of Gibson and Treherne (10) and Treherne (35 and 36). Other early Canadian publications of significance were by Caesar (4) and Brittain (2).

Miles (17, 19, 20, 22, and 23) has recently done considerable work on the bionomics of the cabbage maggot in Great Britain.

Author's observations

The data given in the present paper show that

H. brassicae is the most common and most generally distributed root maggot in British Columbia, Washington, and Oregon.

It is a serious pest of cabbage, cauliflower, radish, rutabagas, turnips, and other cruciferous crops of the Pacific northwest. Cabbage and cauliflower are damaged most severely in the seedbed and in the field early in the season while radish, rutabagas, and turnips are subject to injury throughout the growing season.

Cabbage and cauliflower are frequently killed by root maggot attack and while radishes, rutabagas, and turnips are less likely to be killed by the maggots, their tunnelling in and on the roots renders the roots unfit for market. An extended discussion of root maggot damage to rutabagas is given by King and Forbes (13, p.608 and p.610).

On Vancouver Island, up to 50 per cent of the plants of early cabbage crops are commonly killed by root maggots when control measures are not undertaken and approximately 80 per cent of untreated rutabagas are regularly rendered unmarketable because of root maggot damage.

Description of life stages

Egg

The chorion of the egg of H. brassicae (Fig. 1) is glistening white and shows a coarse longitudinal ribbing. A groove extends along the concave side. The egg is about 1 mm. long and about .35 mm. in diameter.

Larva

There are 3 larval instars which may be easily distinguished on the following basis: The first instar larva is metapneustic and the mouthparts consist of a single median hook with a paired plate on each side. The second instar larva is amphipneustic with the posterior spiracle possessing 2 slits; the mouthhooks are paired and have a number of small teeth on their ventral surface. The third instar larva is amphipneustic with the posterior spiracle possessing 3 slits; the mouthhooks are smooth below.

The full grown larva is about 8 mm. long. It is muscidiform and nearly white. The caudal segment (Fig. 4) bears 7 pairs of fleshy tubercles. One pair, the anal tubercles, arises near the anus. The other 6 pairs are arranged around the posterior spiracular field. The 2 postero-ventral pairs are the most conspicuous because of their position and relatively larger size. The mesal pair of these is bifid. This character serves to distinguish H. brassicae from other Hylemya spp. commonly found on cruciferous plants. The flat, oblique, caudal surface bears the slightly elevated posterior spiracles. Each posterior spiracle (Fig. 8) possesses 3 slit-like openings and a medial button (= ecdysial scar). Each anterior spiracle (Fig. 9) has 10 to 12 digits. The mouthhooks are black and curved and the slit in the upper wing of the pharyngeal sclerite of the cephalo-pharyngeal skeleton (Fig. 16) is long and narrow.

Puparium

The puparium is elongate oval and about 5 mm. in length. It is formed by the hardening and contracting of the integument of the third instar larva so it shows, in a somewhat modified form, the characteristic structures of the third instar larva. The puparium is light brown in color when first formed but darkens progressively until it becomes dark reddish-brown.

Adult, male

The male fly is about 6 mm. in length. Its color is generally dark with grey markings. The eyes are holoptic. The thorax is ash grey and bears three black longitudinal bands on the dorsum. The abdomen is bluntly rounded at the apex and has a quite well marked darker central line. There is a cluster of rather long bristles at the base of the hind femur; this character is useful in separating the males of this species from the males of closely allied forms.

Adult, female

The female fly is about the same size as the male but is lighter in color. The eyes are dichoptic. The striping on the thorax is less distinct than it is in the male. The abdomen is conical at the apex and the cluster of bristles present at the base of the hind femur in the male is absent in the female.

Life history and bionomics

Egg

Caesar (4, p.50) states that the largest number of eggs laid by any one fly observed by him was 117. He adds that egg laying may extend over a considerable period and that 20 or more eggs may be deposited by a female in a day. Miles (19, pp.426-427) was able to observe a female which mated in captivity and found it laid 122 eggs over a period from July 6 to August 25. The majority of these eggs were laid during the first 2 weeks after fertilization.

Treherne's studies at Agassiz, B.C., during 1915 indicated that the egg stage lasts from 2 to 10 days with an average of 4.7 days (10, p.11). Treherne further stated that high egg fertility was maintained throughout the summer. Gibson and Treherne (10, p.12) also found that uniform incubator temperatures from 27°C. to 30°C. gave a variable hatching of from 3 to 5 days. Caesar (4, pp.50-51) working in Ontario stated that the shortest incubation period for eggs he observed was slightly under 48 hours and that under normal conditions nearly all eggs hatched inside a week. Schoene (30, pp.134-136) carried out tests from which he concluded that under field conditions during May and June incubation varied from 3 to 5 days and he states that unusual temperatures would undoubtedly cause greater variations in the time of hatching. Observations by the writer at Victoria during 1950 showed that most eggs hatched in 4 or 5 days.

Treherne's experiments at Agassiz indicated that exceptionally high temperatures decrease the percentage of eggs that hatch (10, p.12). Caesar (4, p.51) states that sunlight and dryness of surroundings are destructive to eggs, approximately 90 per cent of the eggs failing to hatch under these conditions.

Larva

Schoene (30, pp.112-113), on the basis of laboratory and field observations, concluded that under normal conditions the larval stage lasts about 3 weeks, but he also says that a large amount of data was accumulated to show that the extent of this period may be materially altered. Gibson and Treherne (10, p.13) state that their records in Canada indicated that the larval stage varies between 19 and 32 days. Nikitina (25) in Gorki province in Russia found that the larval period lasted 20 to 26 days in the field. Thus, the larval period may be said to last about 3 weeks.

Pupa

When the larva has reached maturity, it transforms into a puparium. Pupation takes place either in the soil close to the root or in one of the superficial feeding tunnels at the surface of the root.

Treherne (10, pp.15-16), in experiments at Agassiz, B.C., found the pupal period varies from 15 to 18 days with some individuals even exceeding this period. He suggested that puparia which are formed in close proximity to the surface, and as a result come in more direct contact with the rays of the sun during the summer months, produce flies sooner than puparia deeper in the soil and away from higher temperatures. He further states that there are indications that there is a marked difference in the length of the pupal stage in the spring and summer as compared with late summer and autumn.

Smith (33, p.317) found that the length of the pupal period was very variable; in the first generation the longest period was 69 days and the shortest 11, while in the second generation the longest period was 18 days and the shortest 7 with an average of 15 days. Nikitina (25) found the pupal stage to last 11 to 20 days in the field in Gorki province in Russia.

Schoene (30, pp.137-147) carried out experiments to determine the effects of temperature and moisture on the development of pupae under field conditions. He concluded that:

1. Differences in soil moisture within wide limits do not alter the length of the pupal period after development has begun.
2. A marked deficiency of moisture, alone or with high temperature also, retards development.
3. A high temperature ..... is unfavourable to normal growth, and seems to cause a retardation in development which may last until low temperature returns.
4. When the conditions are severe or unfavourable, the individual pupae respond differently to the same environment. Thus, certain pupae may finish their development in a shorter time than usual when subjected to a high temperature, while others may aestivate for an indefinite period.
5. Some data has been accumulated to show that a normal period results for a large percentage of the pupae when optimum conditions for this species obtain.

Kozhanchikov (14) describes experiments carried out at Leningrad to determine the influence of temperature and humidity on the development of pupae of H. brassicae.

He found that development proceeded at temperatures ranging from 6° to 30° C. and relative humidities of 6 per cent to 100 per cent, provided that one of these factors was favorable. Optimum temperature was about 20° C. and optimum humidity about 100 per cent. All pupae died at 35.5° C. when the relative humidity was 75per cent. The threshold of pupal development was found to be about 6° C.

It is now generally agreed that H. brassicae regularly overwinters only in the pupal stage, although early writers have held that it overwinters in the larval and adult stages as well as in the pupal stage.

Adult

On Vancouver Island the adults begin to emerge from overwintering puparia during the first long warm interval during April or May. The 1953 spring emergence of H. brassicae adults from several rutabagas caged the previous fall at Victoria, B.C., is shown in Table 5.

The emergence of the flies in the spring is thought to be controlled by the cumulative effects of soil temperature and moisture (20, p.235). Schoene (29, p.136) further suggests that the time the first flies emerge in the spring depends not only somewhat on the weather but also upon such things as the type of soil, depth to which the field had been ploughed, and slope of the land.

Table 5. Emergence of Hylemya brassicae (Bouché) from rutabagas caged on November 13, 1952, at Victoria, B.C.

Date	Number flies emerged
Nov. 13, 1952 to Apr. 16, 1953	0
Apr. 17, 1953	4
20	3
22	3
24	4
25	3
30	3
May 4	1
7	1
11	1
14	4
18	1
21	1
25	0
28	1
June 1	0
4	0
8	2
11	2
June 12 to July 20	0
Total	34

Schoene (30, pp.121-122) has also correlated the emergence of the adults in spring with the time of the flowering of some wild and cultivated fruits (Prunus spp. and related genera) and has found that abnormal seasons affect the emergence of flies and the blooming of tree fruits in much the same way. Miles (19, p.431) suggests that inasmuch as flies may be dependent on nectar for their survival, there may well be a rather intimate association between the time of fly emergence and the time of blossoming of shrubs and fruit trees.

Most of the cabbage maggot flies from overwintering puparia have emerged by the end of May. A few of them, however, may continue to emerge until July or August and a small percentage (about 4 per cent) of overwintering puparia even pass through a second winter before producing adults (4, p.51).

Several workers have conducted experiments to determine the depth of soil through which adults are able to emerge. Washburn (40, p.204) buried puparia out of doors at various depths and found that the flies were not able to emerge through 6 inches of soil under as nearly natural conditions as possible. In experiments conducted at Ottawa, Ontario, however, flies emerged from a depth of 9 inches (10, pp.14-15) and in experiments conducted by Schoene, they emerged from depths as great as 12 inches (30, pp.117-118).

Gibson and Treherne (10, p.17) found the length of life of the adults increased as the season advanced. Thus, the length of life was 2 to 5 days for flies emerging between June 26 and July 1 and 7 to 25 days for those emerging between August 28 and September 27. They found little difference in the life span of flies fed and those not fed after emergence. Schoene (30, p.119) found, however, that when adults were placed in cages without food they lived only 2 to 3 days, but when food and water were supplied the length of life ranged from 2 to 4 weeks. Vodinskaya (38) found that dryness of the air (humidity below 35 per cent) and a temperature of 17°C. are fatal to the adult flies.

The writer has observed the adults in the field on Vancouver Island from April through October. The adults have frequently been observed about the flowers of various weeds, especially wild mustard. Miles (17, p.265) at Wye, England, has taken adults on *Brassica* spp., lettuce, spinach, weeds, around the edges of fields, on heaps of rakings, and on bare soil from early April to early October. Observations of Schoene (30, p.120) have shown that during periods favorable for oviposition, the females are apt to be found on the soil near cruciferous plants, while the males are found largely on the foliage of weeds and shrubs.

Observations made by the writer have shown that the activity of the flies is markedly influenced by weather conditions. Greatest activity was observed when air temperatures were between 65° and 80° F. Strong winds and rain invariably reduced adult activity.

The preoviposition period of the adult female under insectary conditions in British Columbia was observed by Treherne to be about 6 days (10, p.27). In 1953 at Victoria, B.C., when the first adult flies emerged on April 17 (Table 5), the first eggs were noted in the field on the same farm on April 24 (Table 6) giving a preoviposition period of 7 days. Caesar (4, p.50), however, states that the preoviposition period in the field may be as short as 2 days.

Oviposition studies on Vancouver Island, B.C.

Oviposition sites

Field observation has shown that the eggs are generally laid either singly or in fairly large groups in the soil about the roots of crucifers. They are rarely found more than 1 inch from the plant. Under certain conditions, e.g., excessive soil moisture, eggs may be laid upon the aerial parts of the plants.

Date of commencement of oviposition

The date of commencement of cabbage maggot fly oviposition is dependent upon the time of emergence of the flies and upon subsequent weather conditions.

Dates on which eggs were first found in the

Table 6. Date of first *Hylemya brassicae* (Bouché) oviposition on the Mattick farm at Victoria, B.C., 1947-1954.

Year	Date first eggs found
1947	April 23
1948	April 26
1949	April 25
1950	May 8
1951	May 3
1952	April 24
1953	April 24
1954	May 31

field each spring from 1947-1954 at the W. Mattick farm at Victoria, B.C., are given in Table 6. Thus, over an 8 year period at Victoria, the earliest egg laying occurred on April 23, the latest on May 31. Egg laying most commonly commenced during the last week of April.

Egg count data

During 1952 at Victoria, counts of the number of *H. brassicae* eggs around each of 10 marked cabbage plants were made twice weekly from May 1 to September 29. At each counting all the eggs found were removed with a camel hair brush and identified. Counts were also made from 10 rutabagas from August 28 to November 13. A similar procedure was followed in 1953 from April 23 to September 28 for cabbage and from July 15 to November 9 for rutabagas.

The data are presented graphically in Plates V - VIII.

The 1952 data show 3 periods of peak oviposition: one in May, one in July, and one in September. Field observation and field cage experiments showed that these periods followed closely the time of appearance of successive generations of adult flies and thus they may be said to be the periods of peak deposition of the first, second and third generation eggs in 1952.

The 1953 data are not as clear-cut as are those of 1952, but they do indicate 3 periods of relatively heavier oviposition: one toward the end of May, one extending from mid-June to mid-July, and one extending from mid-August to early October. Again field observation and field cage experiments showed that these periods followed closely the appearance, respectively, of overwintering, first, and second generation adult flies. Thus, they represent the periods of greatest deposition of the first, second, and third generation eggs.

It will be noted from the histograms that generally each peak is lower than the one preceding. This is not to be taken that total egg laying was less in each succeeding generation but rather that, as the season progressed, there was present on the farm a progressively greater acreage of cruciferous crops over which the eggs were distributed. Thus, while the total amount of egg laying of each generation may have been equal or even successively greater, the number of eggs to be found on any given 10 plants would tend to become progressively smaller.

Miles (23, pp.720-723) also noted that egg deposition in summer was lighter than that occurring in spring. She states that this low rate of egg laying in summer was not due to lack of adults but suggested that it was due to the fact that, in summer, the environment provides little food to sustain the adults and as a result they do not survive to complete oviposition.

Factors affecting oviposition

In the course of these studies, several factors were observed to affect egg laying of the cabbage maggot fly. Among these factors were size and vigor of the plant, the crop involved, and rainfall and irrigation.

Size and vigor of plant. The size and vigor of the plant seemed to be of some importance in determining the number of eggs that would be laid about it inasmuch as the larger, more rapidly growing plants almost invariably yielded more eggs than did smaller plants that were making poor growth. In this connection, consider Table 7 which gives the May egg counts for 6 cabbage plants. Plants 1, 2, and 3 were small and were growing slowly while plants

Table 7. Actual number of *Hylemya brassicae* (Bouché) eggs found on six cabbage plants at Victoria, B.C., during May, 1952.

Date	Plant number 1	2	3	4	5	6
May 1	2	1	0	0	3	2
5	0	0	0	7	12	9
8	0	3	0	2	36	23
12	8	0	0	1	42	3
15	11	6	0	3	1	28
19	2	0	1	12	7	6
22	13	3	0	24	10	7
26	10	26	25	33	9	33
29	4	9	12	12	27	12
Total	50	48	38	94	147	123

4, 5, and 6 were larger and were growing rapidly. The figures show that during May, 135 eggs were laid on the former group, while 364, or almost three times as many, were laid on the latter group. It is thought that this difference in the number of eggs found may be attributed to the difference in size and growth inasmuch as all other factors, as nearly as could be determined, were approximately identical for both groups of plants.

Also, field observations with rutabagas have consistently shown the importance of plant size in determining the onset of oviposition. As long as the plants are relatively small (say less than 2 inches high) very few, if any, eggs are laid about them. This is so even though heavy egg laying may be taking place in another part of the same field on some other cruciferous crop. Only after the rutabagas are 3 or 4 inches high does any appreciable oviposition commence about them.

Crop. The histograms show that from about August 1 onwards there was considerably heavier oviposition taking place on rutabagas than on cabbages. Both were equally available as oviposition sites. These facts would show that, at least late in the season, rutabagas are preferred to cabbages as oviposition sites.

Rainfall and irrigation. Rainfall and irrigation have marked effects on egg deposition. At Victoria it was found that appreciable rainfall or irrigation was usually followed by an increase in egg laying. Consider particularly the month of July, 1952. On July 7 the peak of the second generation egg laying was reached and from July 7 to July 10 there was a marked decline in egg laying rate. On July 10, however, the field received a 2 hour watering from an overhead sprinkler system and by July 14 there were greatly increased numbers of eggs about the plants. Similarly, a low mark in egg laying was reached by July 21 but on July 22 .69 inches of rain fell and there followed a period of increased egg laying until July 28. After this date egg deposition dropped to a low level at which it remained with only minor fluctuations throughout the hot and dry month of August. Further examples of increased egg laying following rainfall or irrigation were noted during September of 1952 and throughout the 1953 season.

Number of generations and seasonal development

There is considerable geographical variation in the number of generations of H. brassicae that occurs each year. Nikitina (25) records 2 generations a year in Gorki province in Russia while Smith (33, p.319) records 3 generations annually in England. Breakey and Carlson (1, p.39) state there are 4 generations a year in Western Washington and Treherne (10, p.20) states that there is undoubtedly a fourth generation of cabbage maggot each year in the Lower Fraser Valley of British Columbia.

The writer's data indicate that there are at least 3 generations a year on Vancouver Island (see preceding section). In some years there may be a small fourth generation. The presence of this fourth generation is dependent on several factors. The date of commencement of egg laying in spring, temperature and moisture conditions during July and August, and autumn weather conditions are especially important. Temperature and moisture conditions during July, August, and even September are important in this respect inasmuch as very hot dry weather retards (and reduces) the development of the second and third generations. Kozhanchikov (14) has demonstrated delayed pupal development at high temperatures.

It has become increasingly evident that the picture is far from being clear-cut. There is a wide overlap in the generations, especially toward the end of the season. There is sometimes considerable difference between the dates of commencement of spring oviposition even on different farms in the same general locality. Thus in 1947 the first eggs were observed on April 4 on one farm near Victoria but none was found until April 23 on another farm a few miles distant. Occurrences such as this can probably be explained on the basis of differences in soil temperature and moisture at the different locations, but they do add considerable difficulty to the determination of the number of generations that occur in a season.

On Vancouver Island, it is the first generation that is important as a pest of early cabbages and crucifer seed-beds. The second, third and, if present, the fourth generations are important on rutabagas.

Field observations by the writer in the fall of 1953 and observations by Crowell[1], extending through several

1. Crowell, H.H., Associate entomologist, Oregon agricultural experiment station, Corvallis, Oregon. (Unpublished notes, 1947-1954).

seasons, would certainly indicate that there are 4 generations of H. brassicae each year in Oregon.

THE SEED-CORN MAGGOT, HYLEMYA CILICRURA (RONDANI)

Status

Literature synopsis

The seed-corn maggot is found in all arable portions of North America. It also occurs in Bermuda, South America, Europe, Asia, South Africa, and the Hawaiian Islands.

It was at Chateauguay, Quebec, in 1885 that injury caused by the larvae was first noted (10, p.11). Since then seed-corn maggots have been recorded as feeding on a wide range of both living and dead plant materials. An extensive list of these food items is given by Reid (26, pp.7-8). Their preferred foods, however, appear to be sprouting seed and decaying parts of such plants as beans, corn, peas, and potatoes. Furthermore, seed-corn maggots have been found instrumental in the transmission of black leg disease of potatoes (15).

Schoene (28, pp.131-133), in 1916, reported examining a field of cabbage where decayed heads had a number of seed-corn maggots in them but where heads that were not decayed contained only cabbage maggots. On this basis he believed that the seed-corn maggot was largely a secondary pest of cabbage, attacking the plants only after rotten tissues had developed. He pointed out, however, that there was no proof the maggots would not feed on healthy tissue. Brooks (3, p.110) lists H. cilicrura as a species generally present on crucifers only in small numbers along with phytophagous species that cause extensive root damage.

In 1928 Huff (12, pp.625-630) carried out experiments to determine whether or not the action of bacteria was a necessary antecedent to the attack of seed-corn maggots upon potato seed pieces, sprouting corn, and other susceptible plants. He concluded:

> From the results obtained in these experiments it seems necessary to conclude that the presence of bacteria, per se, is not essential to the development and pupation of the larvae of Hylemyia cilicrura. It seems permissible to conclude also that in the nutrition of the larvae of this species, the bacteria by their action on the medium sometimes play the role of preparing a suitable substratum for growth of the larva.
>
> It seems permissible to conclude also that the substances essential to the growth of these larvae are present in bacteria-free, growing seedlings of beans and some other seeds.

It thus becomes necessary to admit the possibility that seed-corn maggots are able to feed on healthy tissue.

The biology and habits of H. cilicrura have been studied by Chittenden (5), Reid (26), and Miles (16 and 18, pp.343-349). Schoene (28) and Tucker (37) have discussed its economic importance while Huff (12) has studied its nutritional requirements.

Author's observations

Seed-corn maggots occurred in considerable numbers in some of the root maggot collections from Vancouver Island but were found in smaller numbers in the Washington and Oregon collections. In the Pacific northwest this species is often a fairly serious pest to sprouting seeds, particularly beans and peas, in backward springs.

Larvae of *H. cilicrura* collected from rutabagas were invariably taken from roots already infested by larvae of *H. brassicae* and/or *H. floralis*. The seed-corn maggots were, moreover, always found with one of the latter 2 species and in no instance were *H. cilicrura* larvae considered responsible for the primary damage to the rutabagas. Thus, *H. cilicrura* larvae, at least on rutabagas, appear to be entirely secondary, feeding on the tissues already damaged by larvae of *H. brassicae* and/or *H. floralis*.

Description of life stages

Egg

The egg of this species (Fig. 2) may be

distinguished from that of H. brassicae by the finely reticulated hexagonal pattern of the chorion. The eggs average 0.92 mm. in length (21, p.83).

Larva

There are 3 larval instars. They may be separated on the same basis as given for separation of the instars of H. brassicae.

The full grown third instar larva of this species tends to be somewhat smaller than a full grown third instar cabbage maggot. It is white in color, cylindrical in shape, tapering anteriorly and obliquely truncated posteriorly. The caudal segment bears 8 pairs of fleshy tubercles -- a pair protruding near the anus, the other 7 pairs arranged around the margin of the posterior spiracular field (Fig. 5). As with the cabbage maggot the 2 pairs of tubercles that protrude from the lower margin are the most conspicuous, but in the case of H. cilicrura, each tubercle of the central pair is single. There is, however, a pair of much smaller tubercles arising somewhat ventrally which are apparent between this pair of central tubercles. These are tubercles "x" of Brooks and account for the fact that there are 8 pairs of tubercles on the caudal segment of H. cilicrura while there are only 7 pairs in H. brassicae. The arrangement and shape of these tubercles on the posterior segment is usually sufficiently characteristic to permit distinction of the species on this basis. The posterior spiracles (Fig. 10) contain 3 slit-like openings but no button. The anterior spiracles (Fig. 11) are said to have 6 to 8 digits (3, p.114) but the writer has never found more than 6. The maggot has a pair of large mouth hooks which are smooth below. The slit in the upper wing of the pharyngeal sclerite of the cephalo-pharyngeal skeleton (Fig. 17) is short and wide.

Puparium

The puparium is somewhat smaller than that of *H. brassicae*, averaging about 5 mm. in length. It is light reddish brown when first formed but grows darker before emergence of the adult. The caudal tubercles are often distinct enough to allow specific determination.

Adult, male

The male fly is 5 to 6 mm. in length. General body color is yellowish grey and there are black bristles on the body and legs. Each segment of the abdomen has a narrow triangular central black marking, these triangles being continuous from segment to segment. The tibia of each metathoracic leg bears a row of bristles on its posteroventral surface. This feature allows separation of the males of this species from those of *H. brassicae* and also accounts for the name "Fringed Anthomyiian" being applied to *H. cilicrura*.

Adult, female

The females tend to be somewhat lighter in color than the males. They are dichoptic and the abdomen is more pointed than it is in the male. The hind tibiae of the female lack the row of bristles which are characteristic of the male. The row of bristles, however, may be represented by 1 or 2 preapical bristles but these are not always present.

Number of generations

Observations indicate that there are 3 generations of this insect a year on Vancouver Island. Adults emerge from overwintering puparia in April and May (Table 8) and the maggots of the first generation shortly become apparent by their damage to bean and pea seeds and seedlings. Two later generations are found feeding on decaying tissues of such crops as turnips and rutabagas. The 1951 root maggot collections at Alberni, B.C., (Table 2) indicate the presence of these 2 later generations.

Table 8. Emergence of Hylemya cilicrura (Rondani) from rutabagas caged on November 13,1952, at Victoria, B.C.

Date	Number flies emerged
Nov. 13,1952 to Apr. 16,1953	0
Apr. 17,1953	0
20	1
22	1
24	1
25	1
30	0
May 4	0
7	0
11	2
14	3
18	3
21	0
25	2
28	0
June 1	0
4	0
8	0
11	0
June 12 to July 20	0
Total	14

THE TURNIP MAGGOT, HYLEMYA FLORALIS (FALLEN)

Status

Literature synopsis

H. floralis is a primary phytophagous species and causes extensive root damage. Brooks (3, p.118) records this species as "the major pest of turnip, cabbage and cauliflower in the prairie provinces, especially in the wooded and parkland sections".

Morrison (24, pp.2576-2584) has given an account of *H. floralis* in northern Scotland where he says it is an important pest of the turnips and rutabagas. He reviews some of the early literature concerning this species.

Author's observations

H. floralis larvae occurred in large numbers on rutabagas during the late summer at Courtenay, B.C., in 1950, 1951, 1952, and 1953. They caused considerable damage to the rutabagas. *H. brassicae* usually occurred along with *H. floralis*, but in 1951 *H. floralis* was the predominant species during late August and early September.

Collections made in north central B.C. in August, 1954, were almost all *H. floralis*. The maggots were causing severe damage to rutabagas and broccoli.

Description of life stages

Egg

The egg of H. floralis is indistinguishable from that of H. brassicae except for its larger size (see key on p. 7).

Larva

The 3 larval instars may be separated on the basis of the spiracles as already described for H. brassicae. The third instar larva of H. floralis is of the same color and general shape as a third instar H. brassicae larva. The caudal segment (Fig. 6) bears 7 pairs of fleshy tubercles -- 1 pair protruding near the anus, the other 6 pairs arranged around the margin of the posterior spiracular field. The large tubercle which is bifid in the case of H. brassicae is more completely divided in H. floralis, the inner division being smaller and appearing as a separate tubercle. Thus the 6 pairs of tubercles arranged around the posterior field appear as 7 pairs. Again, the arrangement and shape of these posterior tubercles is sufficiently characteristic to permit specific determination on this basis. The posterior spiracles (Fig. 12) contain 3 slit-like openings and a button. The anterior spiracles (Fig. 13) have 8 to 12 digits. There is a pair of large smooth mouth hooks associated with a well developed cephalo-pharyngeal skeleton (Fig. 18). The slit of the upper wing of the pharyngeal sclerite of the cephalo-pharyngeal skeleton is long and slender.

Puparium

The puparium of this species may be distinguished from those of other closely related species on the basis of the posterior tubercles (which are the same as those of the third instar larva and which are usually sufficiently distinct to permit specific determination).

Adult

The adults of H. floralis are superficially very similar to those of H. brassicae from which they are separated on the basis of differences in chaetotaxy.

Number of generations

The root maggot collections at Courtenay indicate that there is only 1 generation of H. floralis annually on Vancouver Island. This is in agreement with

Morrison (24, p.2578) for northern Scotland and with Brooks (3, p.118) for the prairie provinces of Canada.

Morrison (24, p.2577-2578) reports that in northern Scotland, the greatest numbers of adults of H. floralis emerge in the first week of August, the maximum egg laying occurs in the second week of August, and the maximum number of larvae appears in the roots in early September.

Collection data for Courtenay (Table 1) indicate that the situation for Vancouver Island is comparable to that of northern Scotland.

HYLEMYA FUGAX (MEIGEN)

Status

Literature synopsis

Brooks (3, p.119) stated that this species was collected only a few times from crucifers in Canada during the years 1947-1950. It was found in Prince Edward Island in 1948 on a cauliflower root and on a dry-rotted turnip; at Agassiz, B.C., in 1949 in brussels sprouts along with H. brassicae; and in Newfoundland in 1950 on turnips.

Miles (18, p.352) has concluded from laboratory rearings and from field observations that H. fugax is a saprophytic species occurring only in an environment that includes one or more primary parasites such as cabbage maggots, cabbage aphids, bacteria, etc.

Miles (18,pp.349-354) has published on the biology and economic status of this species.

Author's observations

A single larva of H. fugax was taken from rutabagas at Victoria on October 28, 1952, and 2 larvae were taken from turnips at Puyallup, Washington, on November 19, 1952.

On November 19, 1953, a collection of maggots was sent to Oregon State College by Ned Frandeen, County Extension Agent for Multnomah County, Oregon, with the notation, "On cauliflower - many growers affected - some years complete crop loss". The writer examined this collection and found all the maggots to be H. fugax (see Table 4). Cauliflower fields in the areas involved were subsequently examined by H.H. Crowell. H. fugax larvae were found alone in furrows in the heads. Only 1 H. brassicae maggot was taken and no signs of other primary parasites were observed. This would indicate that H. fugax was a primary phytophagous species in this instance.

Description of life stages

Egg

The egg of *H. fugax* (Fig. 3) has a distinctly reticulated chorion and the ventral surface is grooved along its entire length. The eggs average 1.06 mm. in length (21, p.84).

Larva

The 3 larval instars may be separated on the basis of the spiracles as already described for *H. brassicae*.

The third instar larva of *H. fugax* is 8 to 9 mm. long. Its cuticle is covered with closely set transparent spines so the larva has a rough woolly appearance, especially when viewed under the microscope. There are 6 pairs of tubercles arranged around the posterior spiracular field (Fig. 7). Five pairs of these are very large and conspicuous. Tubercle "x" is also present; it is large and bifid at the apex. The form and relatively large size of the tubercles and the texture of the cuticle permit specific determination of this maggot. The posterior spiracles (Fig. 14) contain three slit-like openings. They are weakly sclerotized and the button is indistinct.

The anterior spiracles (Fig. 15) have 11 to 13 digits. The mouth hooks are slender and the slit in the upper wing of the pharyngeal sclerite of the cephalo-pharyngeal skeleton (Fig. 19) is short and wide.

Puparium

The puparium of this species may be distinguished on the basis of the posterior tubercles and the spicules of the cuticle.

Adult

The adults are very similar to *H. brassicae* in general appearance. They are greenish-gray, the females being somewhat lighter in color than the males. The chaetotaxy of the thorax and legs serves to distinguish the species from closely related forms (see key, pp.7-8).

Number of generations

Brooks (3, p.119) states that there are 4 to 5 generations of *H. fugax* each year and Miles (18, p.352) says, "it is probable that there are at least four generations a year".

The Oregon State College insect collection contains adult flies taken more or less continuously from

March 28 to November 5. Larvae of this species occurred on cauliflower heads at Portland on November 27, 1953. These facts would indicate that there could well be 4 or 5 generations of this species a year in Oregon.

SOME NOTES ON THE BIOLOGICAL CONTROL OF ROOT MAGGOTS

Climate and weather conditions are very important in the control of root maggot populations. Reference has been made to this in other sections of the present paper.

H. brassicae puparia held in the laboratory have frequently yielded adults of the staphylinid *Aleochara bilineata* Gyll. (= *Baryodma ontarionis* Casey). The percentage parasitism by this beetle for 3 groups of puparia observed is given in Table 9. The adults of this beetle have been observed preying upon root maggots in the field. The life history and habits of this parasite have been studied by Wadsworth (39, pp.1-27) and by Colhoun (6, pp.1-8).

No other parasites have been reared from root maggot puparia from Vancouver Island. *Trybliographa rapae* (Westw.) (Hymenoptera: Cynipidae) is an important parasite of root maggots in other parts of Canada and elsewhere. It has been studied by Wishart and Monteith (43, pp.145-154).

Table 9. Parasitism of _Hylemya_ _brassicae_ (Bouché) by _Aleochara_ _bilineata_ Gyll. at Victoria, B. C., 1952.

Date collected	No. of puparia	Percentage parasitized
June 12	117	6.0
June 27-30	225	14.7
July 23	275	2.2

Predators also have a role in the biological control of root maggots. On July 3, 1952, harvestmen (Arachnida, family Phalangiidae) gained entrance to a fly trap which contained root maggot flies. They devoured the flies leaving only legs and wings. Closer observation of the activities of harvestmen followed and they were observed attacking root maggot flies emerging from the ground and female flies on the ground laying eggs. They fed freely on root maggot flies in cages in the laboratory. Harvestmen are very numerous in cabbage, cauliflower, and rutabaga fields on Vancouver Island and are thus probably important predators of root maggot flies.

Numerous other predators have been recorded in the literature but no specific observations of them has been made by the present writer.

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APPENDIX

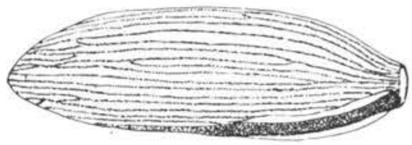
PLATE I

EGG (after Brooks, 1951)

1. *Hylemya brassicae* (Bouché)

2. *H. cilicrura* (Rond.)

3. *H. fugax* (Meigen)



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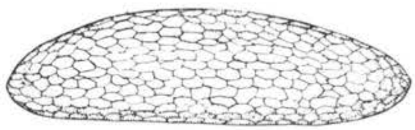

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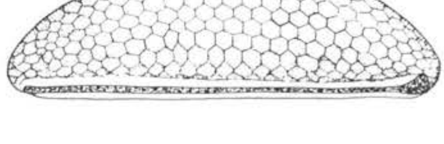

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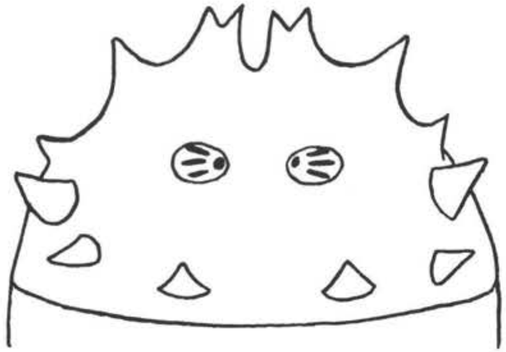
PLATE II

CAUDAL SEGMENT OF THIRD

INSTAR MAGGOT, DORSAL ASPECT

4. *Hylemya brassicae* (Bouché)
5. *H. cilicrura* (Rond.)
6. *H. floralis* (Fall.)
7. *H. fugax* (Meigen)



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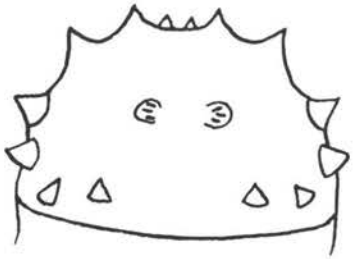

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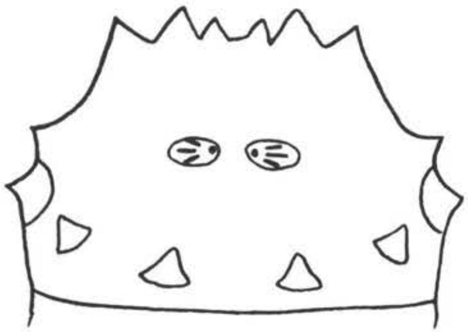

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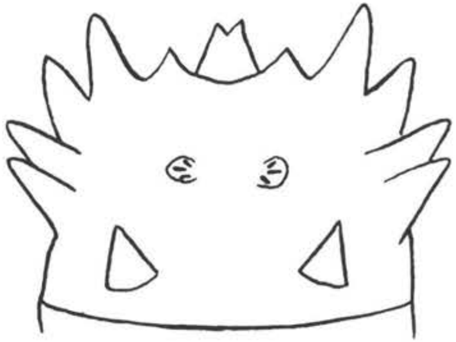

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PLATE III

POSTERIOR AND ANTERIOR

SPIRACLE OF THIRD INSTAR MAGGOT

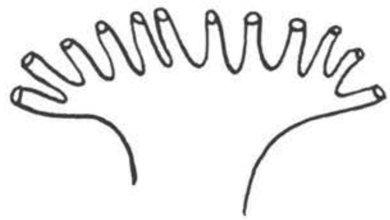
8 and 9. _Hylemya brassicae_ (Bouché)

10 and 11. _H. cilicrura_ (Rond.)

12 and 13. _H. floralis_ (Fall.)

14 and 15. _H. fugax_ (Meigen)

8



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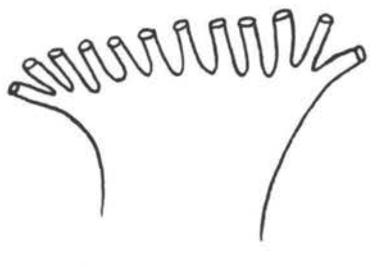

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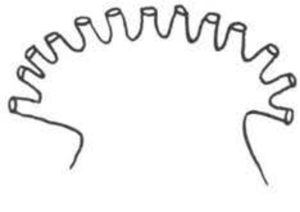

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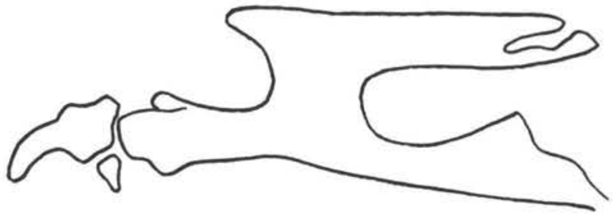
PLATE IV

CEPHALO-PHARYNGEAL SKELETON

OF THIRD INSTAR MAGGOT

16. *Hylemya brassicae* (Bouché)
17. *H. cilicrura* (Rond.)
18. *H. floralis* (Fall.)
19. *H. fugax* (Meigen)

16



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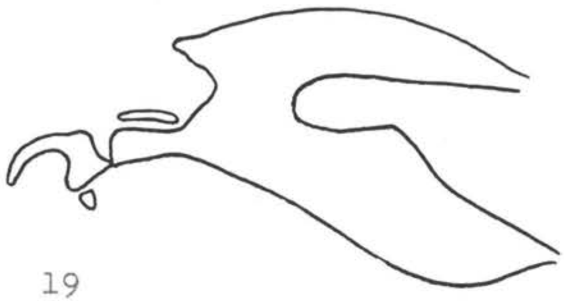

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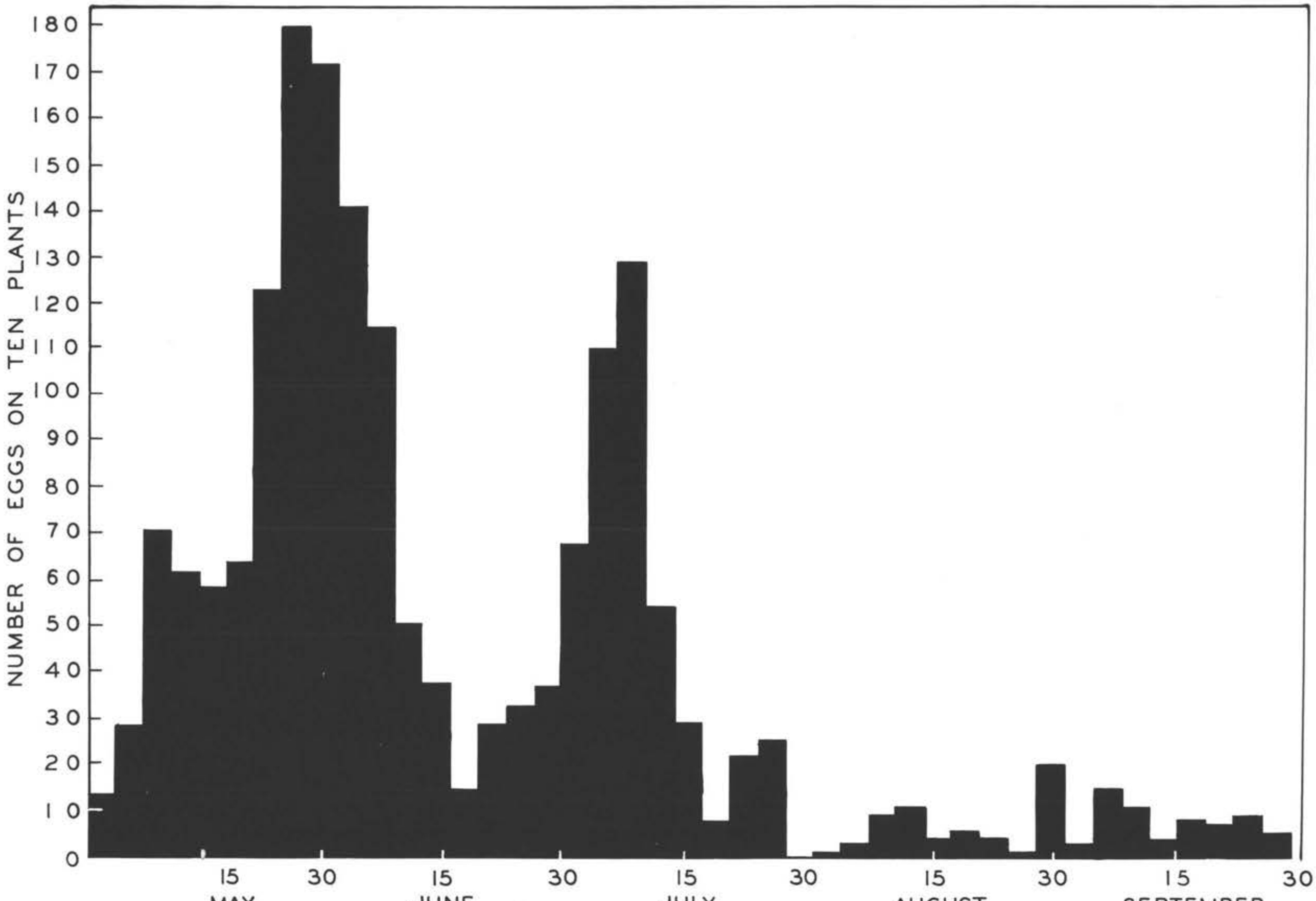
PLATE V



OVIPOSITION OF HYLEMYA BRASSICAE (BOUCHÉ) ON CABBAGES, VICTORIA, B.C., 1952

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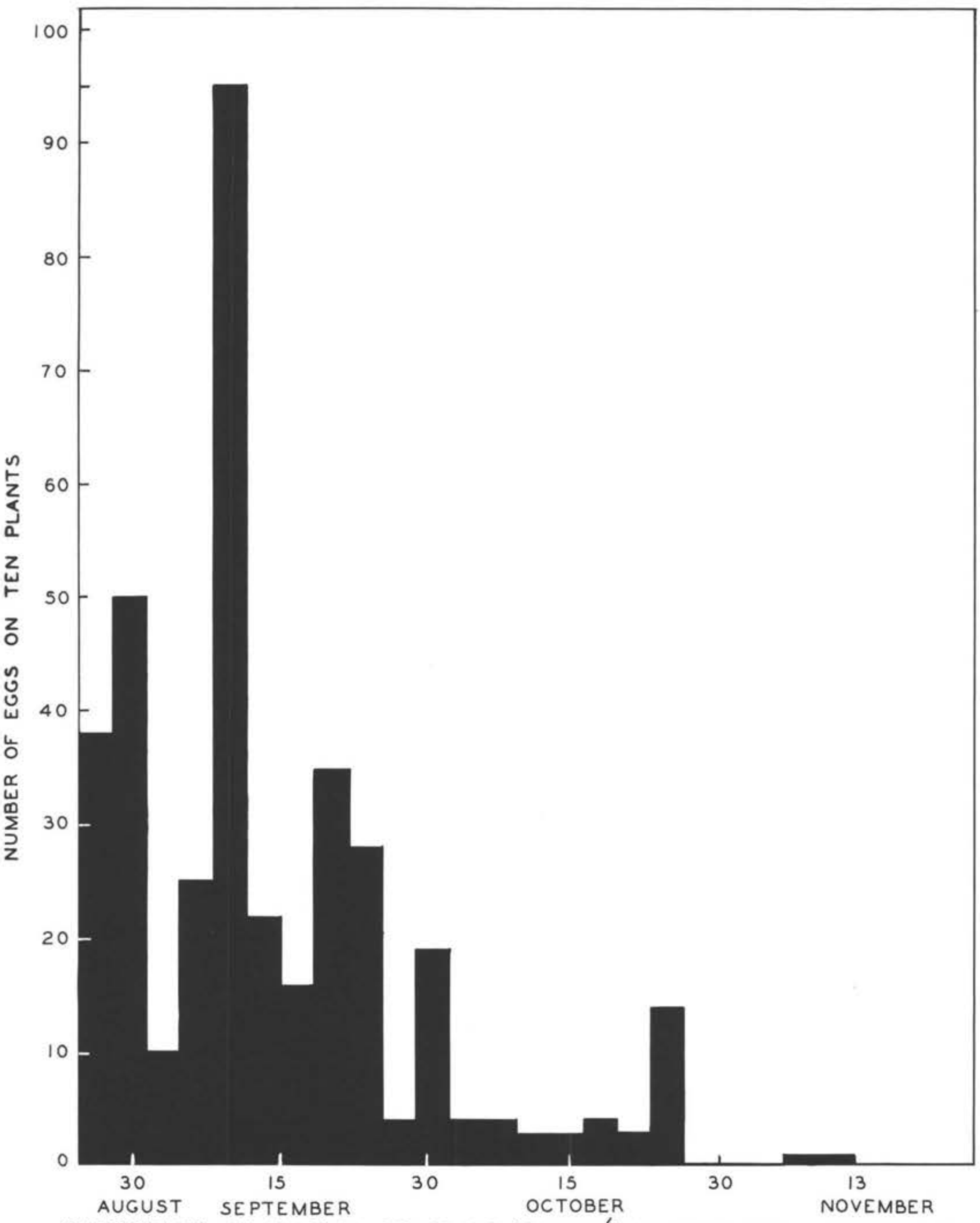
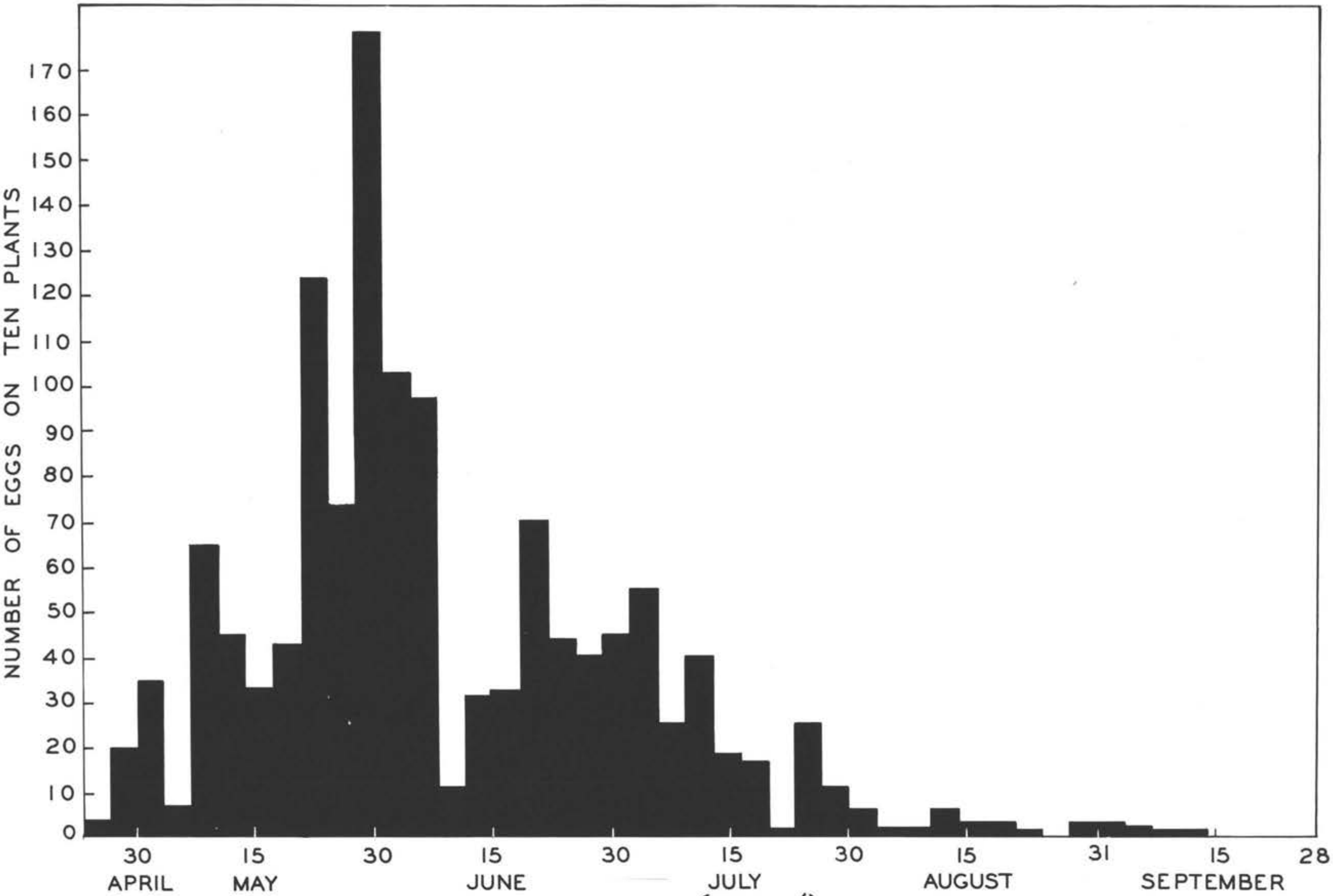
PLATE VI



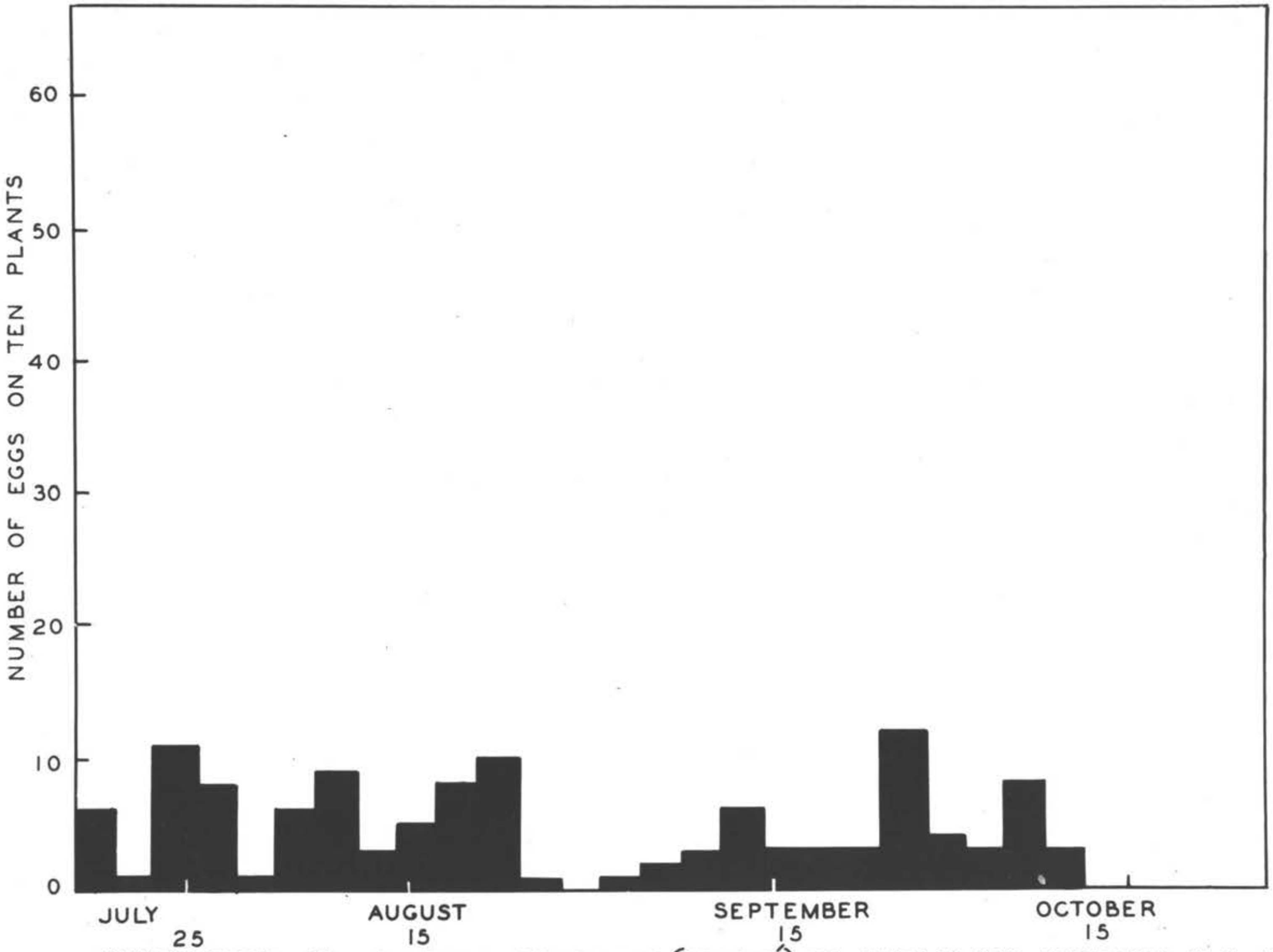
OVIPOSITION OF HYLEMYA BRASSICAE (BOUCHÉ) ON RUTABAGAS, VICTORIA B.C., 1952

PLATE VII



OVIPOSITION OF HYLEMYA BRASSICAE (BOUCHÉ) ON CABBAGES, VICTORIA, B.C., 1953.

PLATE VIII



OVIPOSITION OF HYLEMYA BRASSICAE (BOUCHÉ) ON RUTABAGAS, VICTORIA, B.C., 1953