A STUDY OF THE SPECIES OF AGRILUS COLEOPTERA INFESTING MICHIGAN RASPBERRIES

THESIS FOR THE DEGREE OF M. S.

R. D. SIMMONS

1933

Boelter

Entomology

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Submitted to the faculty of Michigan State College for the partial fulfillment of the degree of M. S.

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ACKNOWLEDGEMENTS

The writer wishes at this time to acknowledge the guidance of Professors R. Hutson and E. I. McDaniel, and to express his thanks for their kindly advice.

Introduction.

Raspberry plants have suffered severely from attacks by the larvae of a beetle known as Agrilus ruficollis for at least 40 years. This has been considered the only important species of Agrilus attacking raspberries. New blackberry, dewberry, and raspberry canes are favorite host plants.

Recently it has been thought that possibly Agrilus communis ab. rubicola Abeille de Perrin, may infest raspberry plants. A. communis is commonly known as the "Rose Stem-girdler."

The work of the two species is almost identical. In the larval stages A. communis and A. ruficollis resemble each other very closely. In the adult stage they can be distinguished without much trouble.

The study presented in this thesis aims to do two things: (1) to present all the available material concerning the species of Agrilus either infesting raspberries or thought to infest raspberries to date, and (2) by breeding to determine which species of Agrilus attack Michigan raspberry plants. The latter will be determined from observations made on material gathered from the entomological experimental patch at Michigan State College and from plantings in the vicinity of East Lansing.

Synonomy.

Agrilus ruficollis Fabricius 1787 (10,22)[1] is also known as Rubi podagra Riley (15,17). Commonly, it is called red-necked cane-borer (1,7,14,16,18,21), red-necked blackberry-borer (11,20), and red-necked Agrilus (11), and its work is sometimes known as gouty gall (15,16,17,20).

Early History.

A. ruficollis is a native insect that has been found infesting raspberries, blackberries, and dewberries (7,15, 16). This beetle was first described in the year 1787. Not much was known about it, however, until about 59 years later. It became known as an injurious pest in 1846, but was not considered as an extremely serious pest until 1870 (22).

It is probable that the original food plants of A. ruficollis were wild raspberries and wild blackberries (7), for at the present time they serve as host plants for it. When cultivated berry bushes are planted in proximity to infested wild ones it would seem an easy matter for the beetles to change over from the wild bushes to the cultivated ones.

Distribution.

Distribution reports indicate that A. ruficollis is confined to the eastern part of the United States.[2]

Food Plants.

A. ruficollis has been found infesting raspberry, blackberry, and dewberry bushes. It attacks both the wild and cultivated varieties of raspberry and blackberry plants (1,2,3,7,13,14,15,16,17,18,21). There have been three doubtful reports of its infesting rose (3).

Injury and Losses.

The most characteristic part of the injury is the gall. These galls are formed by the stimulation of cambium growth, due to the presence of larval burrows (1,6,10,12,15,16,17,19). One shoot may have one to many galls on it (3,16). They are generally found near the base of the shoots at first. Later they may be found on the upper part of the shoots and even on the lateral (3,19,22). The galls measure anywhere from 1 to 3 inches in length (7,18,19). After development

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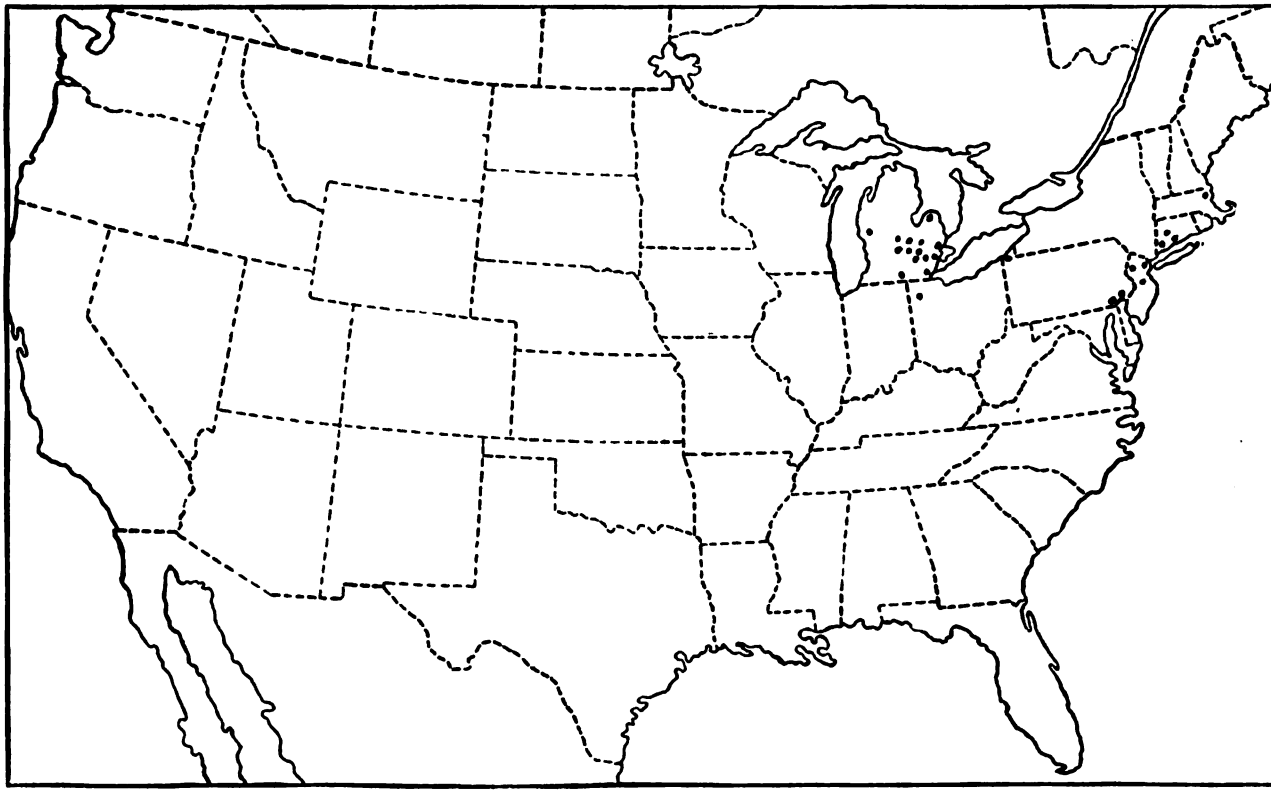
1. Figures in parenthesis refer to references.
2. See map on page following PAGE 11.



Distribution of A. communis, as determined by distribution maps obtained from J. A. Hyslop, Insect Pest Survey, Bureau of Entomology, Washington, D. C., and records in the M. S. C. Department of Entomology.

and enlargement, the bark splits longitudinally over the galls (6,7,10,12,13,15,16,17,18,21).

The shape of the tunnel is characteristic of those made by all flat-headed borers, being of flattened cross section to permit passage of the enlarged prothorax.

- Infested shoots may start to leaf out, but the foliage will not have its characteristic healthy appearance. The infested shoots have generally been found unable to mature fruit (1,15,16,19,20). These shoots may die prematurely, depending on the seriousness of the girdle (13,14,15,16,18). A heavy wind or snow storm will break the shoots off at the girdled places (13). In fact some of them will snap off when only lightly touched with the hand.

The beetles have been known to feed upon the upper surfaces of young, bright green leaves. They either notch or cut little round holes in the leaves, and leave excrement on its upper surface. The leaves wither and die. Unlike most buprestids these beetles feed on the foliage in either shade or sunlight (3,7,19).

In time a whole bramble patch or plantation may be ruined by A. ruficollis.

Description of the Various Stages.

A. ruficollis adults range anywhere from 1/4 to 1/3 inches in length (1,4,5,7,11,13,14,15,16,18,21). The elytra are black and have a dull bluish reflection (1,2,4,5,7,11,12,13,14,15,16,17,18). The thorax is reddish or brassy, and this is how it came to be called the red-necked cane-borer (1,2,7,11,12,13,14,15,16, 17,18). The head is black and has metallic reflections on the front(4,5,11,18). The antennae and legs are black. The ventral surface of the beetle is also black (11,17).

The adult larva is yellowish-white, slender, and has a flattened anterior end due to the enlargement of the prothorax (7,11,15,16,17,18,21). It has black jaws and a brown head (11,16,17,18,21). Two brown hooks are found on the tip of the abdomen (7,11,15,16,17,18). There are three blunt teeth on their inner edges (11,17).

Not much is known about the egg to date as no literature has been published on it.

Life History and Habits.

The adults emerge around the last of May or the first of June. Eggs are laid in June and July in young shoots. These eggs are deposited at the bases of the leaves (7,8, 11,13,14,15,16,17,18,21,22).

The larvae emerge in late June and July. They burrow toward the tips of the shoots (7,15,16,18). Several larvae may be in one shoot (13,21). In traveling up the shoots the larvae go around and around in the sapwood. Some go to the right and some to the left (19). This is called spiral burrowing. These spirals go around the shoot anywhere from two to five or six times and galls appear as a result of their interference with the trans location of food in the plant (13,14,18,19).

This interference with the translocation of food in the plant is what causes girdling to take place, because the food supply is cut off (14,18). The bark splits longitudinally over the galls on blackberry and dewberry shoots. It also does this some on raspberry shoots (7,15, 16,17,18,21).

After completing two to six spirals in the sapwood the larvae enter the pith and continue up the shoot. At frequent intervals they go to the edge of the pith and feed on the sapwood (15,16). Slender white larvae are found above the galls at distances varying from 1 to 6 inches.

The galls will start to show up in early August. Occasionally the injury does not form a gall. In this case the larvae will be found in the pith (15,16).

Late in the fall the larvae are found in the pith above the galls. Here they pass the winter months (13,15, 16,18,21,22). They molt in March and form shorter larvae, which are called prepupal larvae. They molt again and change to pupae in April. This stage lasts about 7 to 10 days (3). As has been said before, the adults emerge in late May and June.

Number of Generations.

So far only one generation of A. ruficollis has been found (3,7,13). There may be another generation in the southern most range of these beetles, but this has not been determined as yet.

Hibernation.

A. ruficollis hibernates as a larva. The hibernation period is passed in the pith of the host plant (11,15,16, 18,21).

Natural Enemies.

The following insects are thought to be parasitic on A. ruficollis: (1) Microbracon xanthostigmus Cresson, and (2) Charitopus magnificus Ashmead (3,8,22). These parasites are small, wasp-like, and have four wings.

Birds may be natural enemies of the species in the adult and larval stages. This is especially true of the larvae that may be in or just above the galls when the canes are first broken off.

Control Measures.

The common practice of pruning and burning berry canes checks the spread of the A. ruficollis beetle, if applied diligently every year.

For A. ruficollis the following measures should be applied:

1. Cut and burn all infested canes in the fall, winter, or early spring (1,2,3,4,5,6,7,10,12,13,14,15,16,17,18, 20,21).
2. Cut and burn any wild berry bushes nearby that might be infested (2,7,14,15,16,18,21).
3. Cut off all new shoots at the surface of the ground. This should be done about the last of June (12,20).
4. Spray canes with lead arsenate (2½ lbs./100 gals. of water), (7).

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Synonomy.

Agrilus communis variety rubicola Abeille de Perrin, 1897 (3) is also known as A. viridis variety fagi Ratzeburg, 1839 (3) and as A. politus Say, 1825 (3). Commonly, it is called the "Rose stem-girdler".

Early History.

A. communis is native to Europe (2,6). It was found in the United States in 1913, in the state of New Jersey. This insect is a serious pest on rose bushes in Europe (6). It is spreading very fast in the United States, and has caused considerable trouble in the east (6,7).

It was collected from raspberry in 1932 and bred from raspberry in 1933. It is thought that possibly this buprestid may become a serious pest of berry bushes as well as rose bushes, because the species of Agrilus have so much in common, and because both the rose and the berry belong to the family "Rosaceae".

Distribution.

A. communis has been found only in northeastern United States according to distribution reports (2,6,7,8).*

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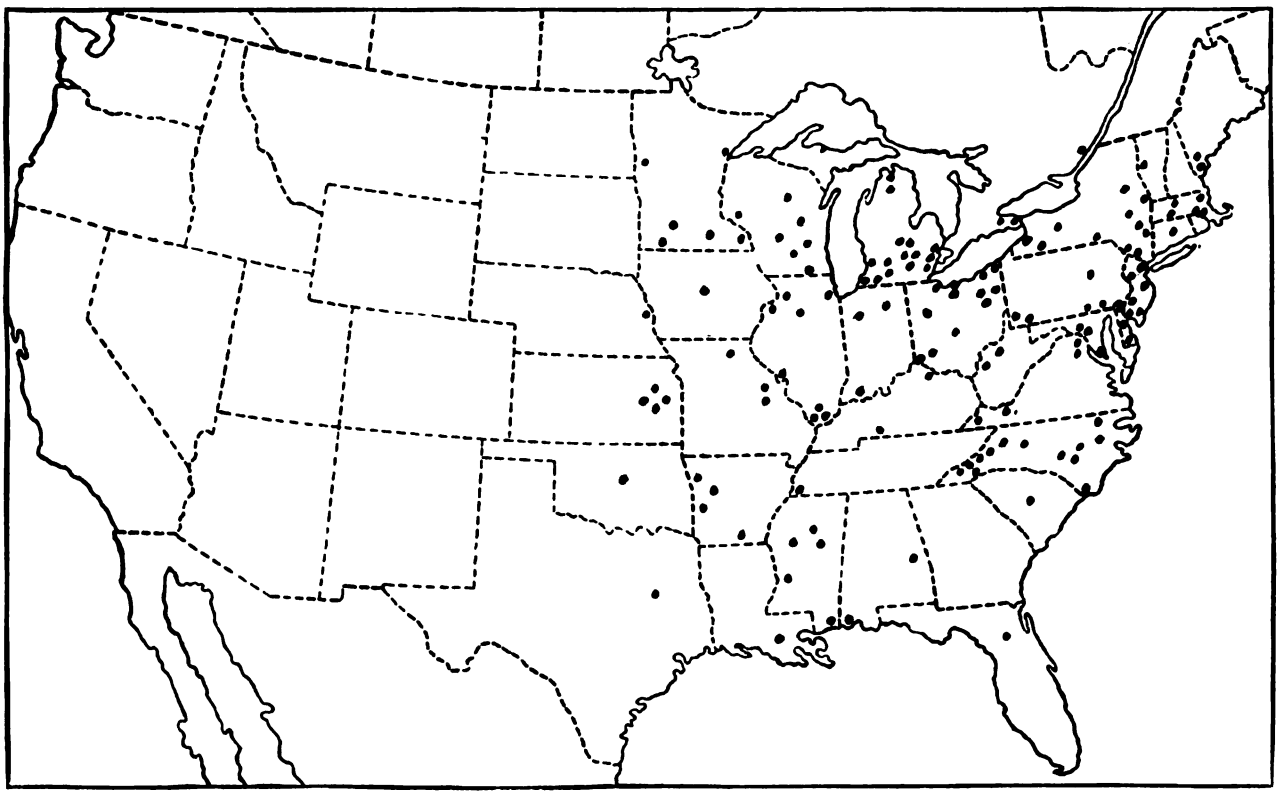
* See map following. PAGE 3.



Distribution of A. ruficollis, as determined by distribution maps obtained from J. A. Hyslop, Insect Pest Survey, Bureau of Entomology, Washington, D. C., and records in the M. S. C. Department of Entomology.

Food Plants.

The only previously reported food plants for A. communis are different varieties of rose bushes such as the following: Rosa blanda, R. nitida, R. setigera, R. multiflora japonica, R. hugonis, R. rubrafolia, R. rugosa, and R. carolina (wild rose), (3,5,6,7,8). This buprestid beetle has been found to be most serious on Rosa rugosa stock (2,3,6).

Injury and Losses.

The injury caused by A. communis is similar to that caused by A. ruficollis. The galls are the most characteristic part of the injury. These galls differ from those caused by the work of A. ruficollis, in that they are found any place on the shoot (4). They are formed, as on raspberry shoots, by the stimulation of the cambium due to the presence of the larval tunnels. More than one gall may be found on a shoot (6). After the gall enlarges the bark splits longitudinally over it (1,2,6,7,8). Girdled shoots break quite easily (2,6).

A shoot with one or more galls will not show characteristic healthy foliage. The leaves turn yellow and die (2,6,7).

Description of the Various Stages.

The adult A. communis varies from 3/16 to 1/4 inch in length. It has brassy-colored elytra with metallic reflections (1,2,3). The head, thorax, and legs are also of the same color. The ventral surface of the body has a very decided metallic coloration. Even the antennae are of a brassy hue (3).

The larva of A. communis is similar to that of A. ruficollis. It is 5/8 to 3/4 inches long and has about the same colorations (6).

The shortest diameter of the egg is 1/25 of an inch. It is oval in shape and looks like a scale insect (4).

Life History and Habits.

The adults begin to emerge about June 1st. (6). The eggs hatch in the latter part of June and in early July. The larvae make spiral burrows around the rose shoots much the same as the A. ruficollis larvae do A-round the raspberry shoots (6). These burrows are 1 to 2 1/2 inches long and are close together (2,6).

Hibernation.

A. communis hibernates as a larva in the pith of the canes.

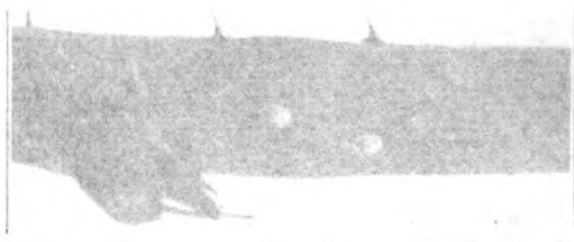


PLATE I

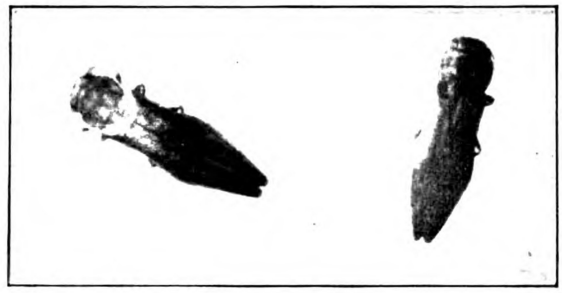


Fig. 1.—Adult of Imported Rose Stem-girdler
(Enlarged)

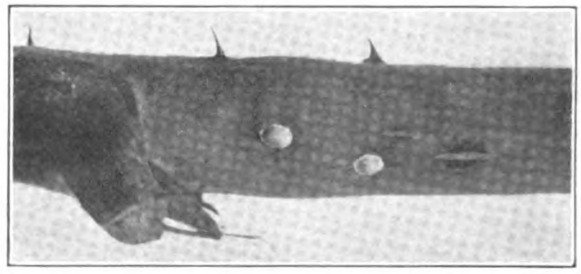


Fig. 2.—Eggs of new pest on raspberry canes
(Enlarged)

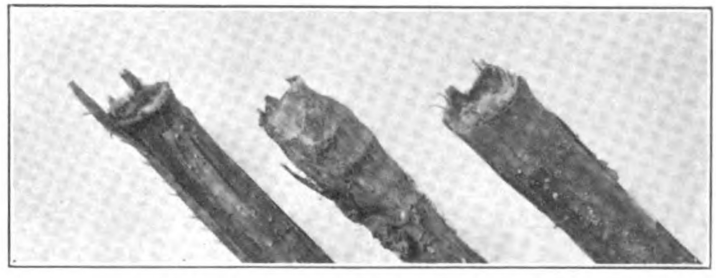


Fig. 3.—Cane injury caused by new pest

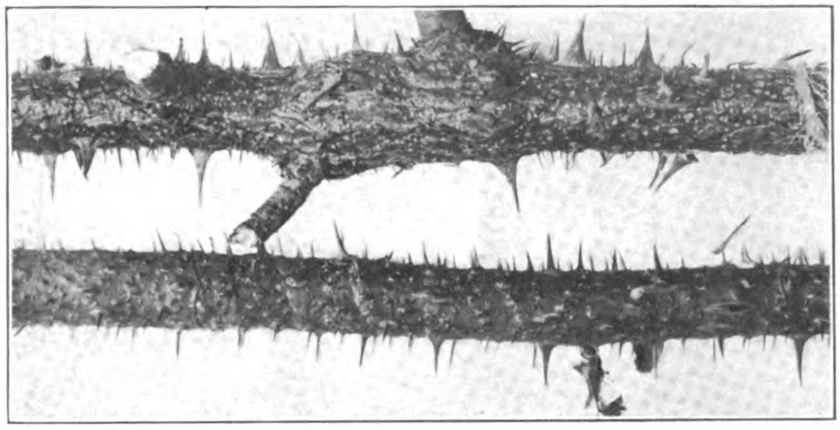


Fig. 4.—Work of Imported Rose Stem-girdler. Upper twig shows characteristic gall, lower twig the spiral tunnel.

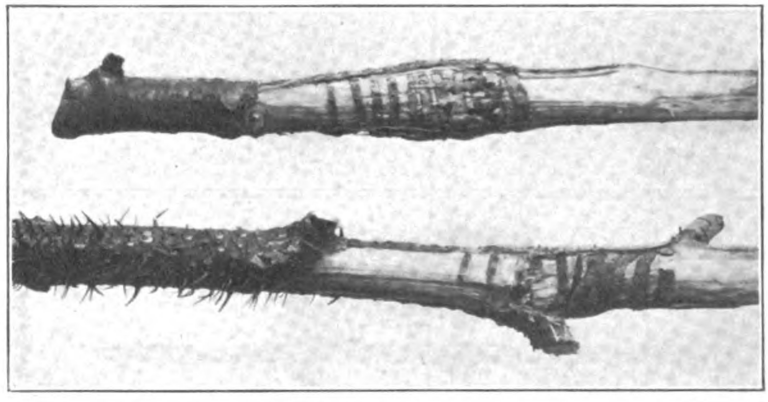


Fig. 5.—Bark removed to show the tunnels of the Imported Rose Stem-girdler

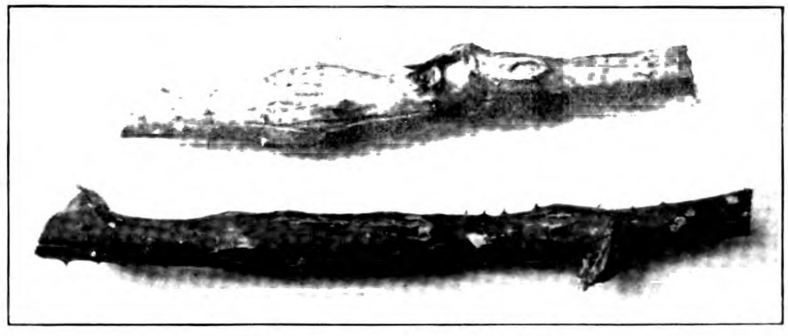


Fig. 6.—Gouty gall on dewberry

Natural Enemies.

Up to the present time no parasites have been found infesting A. communis. Birds may be a natural enemy to the larvae and to the adults.

Control Measures.

For A. communis the following measures should be applied:

1. Prune out infested rose canes and burn before spring sets in (2,6).
2. Cut and burn any wild rose bushes nearby that might be infested.

References.

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Experimental Work.

The experimental work was planned to clarify the question suggested by the second part of this study as stated in paragraph 4, on page 1.

Methods, Apparatus, and Procedure.

Material was gathered from five different sources: (1) raspberry canes from the entomological experimental patch, (2) raspberry canes from the horticultural "50" patch, (3) raspberry canes from the east horticultural patch, (4) rose canes from the Botanical Gardens, and (5) wild blackberry canes from the railroad track alongside of the entomological experimental patch. This material was put in separate bell jars in a hatchery at a constant temperature of 75-80 degrees F. A thermostat regulated this constant temperature in the hatchery.

Data were collected from this material and put in tabular form under the following headings: (1) number of canes, (2) number of infested canes, (3) per cent of infested canes, (4) number of broken canes, (5) per cent of broken canes, (6) number of galls in each bell jar, (7) emergence of beetles, (8) emergence of parasites, (9) per cent of emergence of beetles, (10) distance from exit hole to the gall, (11) length of tunnel, (12) distance the beetle came back down the tunnel (those that did), and (13) size of exit hole (long and short diameters).

The principal experimental material was taken from the entomological experimental patch. The two horticulture patches were used as checks. The wild blackberry and rose canes collected, were also used as checks.

The entomological experimental patch consists of one row of red raspberries, which is approximately 66 paces long. This was divided up into 11 plots of 6 paces each. Six of these were used for experimental work (1,3,5,7,9,11), After figures were obtained from these plots the other five were averaged in.

The horticultural "50" patch consists of 7 rows of red raspberries. Each row averages about 54 paces in length. Three of these rows (1,4,7) were divided into 9 plots of 6 paces each. In these rows (1,4,7) were

divided into 9 plots of 6 paces each. In these 9 plots data were taken from 5 of them. The other 4 plots in the three rows were then averaged in. Then the remaining four rows were averaged in with the three rows used.

In the horticultural patch of red raspberries east of the horticulture building the red raspberry canes are planted in hills. This patch is made up of 4 rows of berry bushes, each row having about 44 hills. Two rows were used (1,3). These rows were split up into half rows of 22 hills each. Data were collected from one half or 22 hills in rows 1 and 3. Then the other half of these rows were averaged in. Finally, the remaining two rows (2,4) were averaged in.

Material was gathered from the wild patch of blackberry canes alongside of the entomological experimental patch, but no special dimensions were taken on the size of the patch or on the number of canes.

This was also true of the rose canes taken from the Botanical Gardens.

Data.

The following data is indicative of the damage done by the Agrilus species from the entomological experimental patch:

I No. of Canes.

(1) 62 canes.

(2) 70 "

(3) 117 "

(4) 77 "

(5) 114 "

440 " in 5 plots. 440 times 11/5 equal 968 canes in 11 plots.

The average number of canes per plot is 88. The lowest number is in plot (1) with 62 canes. Plot (3) has the highest with 117 canes.

II No. of Infested Canes.

(1) 25 canes infested.

(2) 34 " "

(3) 40 " "

(4) 27 " "

(5) 33 " "

159 " " in 5 plots. 159 times 11/5 equal 349.8 canes infested in 11 plots.

The average number of infested canes per plot is 31.8. Plot (1) has the lowest number with 25 infested canes. The highest is 40 in plot (3).

III Per cent of Infested Canes.

349.8
---- times 11 equals 36. per cent infestation in
968 the entire patch.

Dividing the number of infested canes by the total number of canes gives approximately 36 per cent infestation for the entire patch.

IV No. of Broken Canes.

(1) 20 canes.
(2) 28 "
(3) 27 "
(4) 17 "
(5) 20 "

112 " broken in 5 plots. 112 times 11/5 equals 246.4 canes broken in 11 plots.

The average number of broken canes per plot is 22.4. The lowest number is in plot 4, which has 17 broken ones. The highest is in plot (2) with 28 broken ones.

V Per cent of Broken Canes.

246.4
----- times 100 equals 70 per cent infested canes
349.8 broken in 11 plots.

Dividing the number of broken canes by the number of infested canes gives the per cent of breakage. This is approximately 70 per cent for the entire patch.

The following data shows the damage done by the Agrilus species in the horticultural "50" patch, which was used as one of the checks.

I Total No. of Canes.

(1) Row 1.	(2) Row 4.	(3) Row 7.
(a) 88 canes.	(a) 76 canes.	(a) 92 canes.
(b) 91 "	(b) 64 "	(b) 89 "
(c) 56 "	(c) 81 "	(c) 74 "
(d) 65 "	(d) 68 "	(d) 79 "
(e) 70 "	(e) 82 "	(e) 66 "
370 " in 5 plots.	371 " in 5 plots.	400 " in 5 plots.
370 times 9/5 equals 666 canes in 9 plots.	371 times 9/5 equals 667.8 canes in 9 plots.	400 times 9/5 equals 720 canes in 9 plots.

666 plus 667.8 plus 720 equals 2,053.8
2,053.8 times 7/3 equals 4,792.87 total no. of canes in 7 rows.

The average number of canes per plot in row 1 is 74, in row 4 it is 74.2, and in row 7 it is 80. The average number of canes per plot in the entire 7 rows is 76.1. The lowest number of canes in row 1 is found in plot (c) which has 56, and the highest is in plot (b) with 91. The lowest number in row 4 is in plot (b) with 64 and the highest is in plot (e) with 82, The lowest figures in row 7 are found in plot (e) with 66, and the highest in plot (a) with 92.

II No. of Infested Canes.

(1) Row 1.

(a) 24 canes infested.	(a) 18 canes infested.	(a) 25 canes infested.
(b) 31 " "	(b) 44 " "	(b) 31 " "
(c) 29 " "	(c) 19 " "	(c) 40 " "
(d) 31 " "	(d) 35 " "	(d) 37 " "
(e) 34 " "	(e) 43 " "	(e) 35 " "
149 " " in 5 plots.	159 " " in 5 plots.	168 " " in 5 plots.
149 times 9/5 equals 268.2 canes infested in 9 plots.	159 times 9/5 equals 286.2 canes infested in 9 plots.	168 times 9/5 equals 302.4 canes infested in 9 plots.

268.2 plus 286.2 plus 302.4 equals 856.8
856.8 times 7/3 equals 1,999.2 total no. of infested canes in 7 rows.

In row 1 the average number of canes is 29.8, in row 4 it is 31.8, while in row 7 it is 33.8. The average number of infested canes per plot in the entire patch is 31.7. The lowest number of infested canes found in row 1 is 24 in plot (a), and the highest is 34 in plot (e). The lowest number in row 4 is 18 in plot (a), while the highest is 44 in plot (b). In row 7 the lowest number of infested canes is found in plot (a) with 25, while plot (c) has 40 infested canes for the highest number.

III Total per cent of Infestation in the entire patch.

1,999.2
-------- times 100 equals 41.7 or 42 per cent total
4,792.87 infestation.

Divide the total number of infested canes in the entire patch by the total number of canes in order to get the per cent. This is 42. per cent for the entire patch.

IV No. of Broken Canes.

(1) Row 1.	(2) Row 4.	(3) Row 7.
(a) 19 broken.	(a) 14 broken.	(a) 16 broken.
(b) 14 broken.	(b) 12 "	(b) 18 "
(c) 15 "	(c) 26 "	(c) 20 "
(d) 17 "	(d) 24 "	(d) 25 "
(e) 20 "	(e) 28 "	(e) 15 "
85 " in 5 plots.	104 " in 5 plots.	94 " in 5 plots.
85 times 9/5 equals 153 broken canes in 9 plots	104 times 9/5 equals 187.2 broken canes in 9 plots.	94 times 9/5 equals 169.2 broken canes in 9 plots.

153 plus 187.2 plus 169.2 equals 509.4
509.4 times 7/3 equals 1,188.6 total number of broken canes in the 7 rows.

The average number of broken canes in row 1 is 17, in row 4 it is 20.8, while in row 7 it is 18.8. The average per plot for the 7 rows is 18.9. The lowest number of broken canes in row 1 is 14 in plot (b), while the highest is 20 in plot (e). The lowest number in row 4 is 12 in

plot (b), while plot (e) is the highest with 28. In row 7 the lowest is 15 in plot (e) and the highest is 25 in plot (d).

V Total per cent of Broken Canes in the Entire Patch.

$$\frac{1188.6}{1999.2} \text{ times } 100 \text{ equals } 59 \text{ per cent broken canes.}$$

By dividing the total number of broken canes in the 7 rows by the total number of infested canes in these rows, the per cent of broken canes was found to be 59 for the entire patch.

The following data is taken from the east horticultural patch, which was also used as a check.

I Total No. of Canes.

1. Row 1.

(1)	20 canes.	(9)	15 canes.	(17)	22 canes.
(2)	18 canes.	(10)	18 "	(18)	24 "
(3)	17 "	(11)	16 "	(19)	23 "
(4)	19 "	(12)	20 "	(20)	25 "
(5)	15 "	(13)	22 "	(21)	22 "
(6)	18 "	(14)	23 "	(22)	24 "
(7)	16 "	(15)	21 "		440 "
(8)	17 "	(16)	25 "		

440 times 2 equals 880 canes in the row.

2. Row III.

(1) 18 canes.	(9) 21 canes.	(17) 21 canes.
(2) 17 "	(10) 22 "	(18) 20 "
(3) 15 "	(11) 18 "	(19) 25 "
(4) 18 "	(12) 17 "	(20) 21 "
(5) 16 "	(13) 18 "	(21) 15 "
(6) 21 "	(14) 18 "	(22) 21 "
(7) 22 "	(15) 20 "	423 "
(8) 21 "	(16) 18 "	423 times 2 equals 846 canes in the row.

3. 880 plus 846 equals 1,726 canes in rows I and III. 1,726 times 2 equals 3,452 canes in the entire patch.

The average number of canes per hill in row I is 20, and in row III it is 19.2, The average number per hill in the entire patch is 19.6. The lowest number of canes in row I is found in hills (5) and (9), with 15 canes each. The highest is in hills (16) and (20), with 25 canes each. The lowest number in row III is found in hills (3) and (21) with 15 each, while hill (19) has the highest with 25 canes.

II Total No. of Infested Canes.

1. Row 1.

(1) 3 infested.	(4) 5 infested.	(7) 5 infested.
(2) 5 "	(5) 5 "	(8) 6 "
(3) 4 "	(6) 6 "	(9) 4 "

(10) 5 infested.	(15) 7 infested.	(20) 8 infested.
(11) 4 "	(16) 7 "	(21) 7 "
(12) 9 "	(17) 6 "	(22) 8 "
(13) 7 "	(18) 7 "	132 "
(14) 8 "	(19) 6 "	132 times 2 equals 264 infested canes in the row.

2. Row III.

(1) 6 infested.	(9) 3 infested.	(17) 5 infested.
(2) 5 "	(10) 5 "	(18) 7 "
(3) 3 "	(11) 4 "	(19) 6 "
(4) 4 "	(12) 6 "	(20) 6 "
(5) 4 "	(13) 7 "	(21) 8 "
(6) 7 "	(14) 8 "	(22) 9 "
(7) 5 "	(15) 7 "	125 "
(8) 4 "	(16) 8 "	125 times 2 equals 250 infested canes in the row.

3. 264 plus 250 equals 514 infested canes in rows I and III.
514 times 2 equals 1,028 infested canes in the entire patch.

In row I the average number of infested canes is 6, while in row III it is 5.7. In the entire patch the average is 5.8. Hill (1) has 3 infested canes for the lowest number in row I, while the highest number is 9 in hill (12). In row III the lowest number is in hills (3) and (9) with 3 infested canes, while the highest is 9 as found in hill (22).

III Total per cent Infestation in the Entire Patch.

1,028
----- times 100 equals approximately 30 per cent
3,452 total infestation.

This was found to be 30 per cent, approximately. The figure was arrived at by dividing the total number of infested canes in the 4 rows by the total number of canes in these rows.

IV Total No. of Broken Canes.

(1) Row 1.

(1) 2 broken.	(9) 4 broken.	(17) 4 broken.
(2) 3 broken.	(10) 4 "	(18) 5 "
(3) 3 "	(11) 3 "	(19) 3 "
(4) 2 "	(12) 5 "	(20) 5 "
(5) 4 "	(13) 3 "	(21) 4 "
(6) 4 "	(14) 4 "	(22) 6 "
(7) 3 "	(15) 5 "	84 "
(8) 3 "	(16) 5 "	84 times 2 equals 168 broken canes in the row.

(2).Row III.

(1) 3 broken.	(7) 4 broken.	(13) 5 broken.
(2) 4 "	(8) 3 "	(14) 5 "
(3) 3 "	(9) 3 "	(15) 4 "
(4) 3 "	(10) 3 "	(16) 6 "
(5) 2 "	(11) 2 "	(17) 4 "
(6) 4 "	(12) 3 "	(18) 4 "

(19) 3 Broken.
(20) 4 "
(21) 5 Broken.
(22) 5 "
82 "

82 times 2 equals 164 broken canes in the row.

(3) 168 plus 164 equals 332 broken canes in rows I and III.
332 times 2 equals 664 broken canes in the entire patch.

There is an average of 3.8 broken canes in row I, and 3.7 in row III. The entire patch has an average of 3.8 broken canes per hill. Row I has the lowest number of broken canes in hills (1) and (4), each having only 2. The highest number of broken canes is found in hill (22), which has 6. Row III has 2 broken canes in hills (5) and (11) for the lowest number, and 6 in hill (16) for the highest.

V Total per cent of Broken Canes in the Entire Patch.

$\frac{664}{1,028}$ times 100 equals 65 per cent broken canes.

By dividing the total number of broken canes in the entire patch by the total number of infested canes, it appears that approximately 65 per cent of the infested canes break.

Number of galls gathered and put in bell jars.

1. Approximately 244 galls on the red raspberry canes from the experimental patch.

2. Approximately 70 galls on the rose canes from the Botanical Gardens.

3. Approximately 96 galls on the red raspberry canes from the east horticultural patch.

4. Approximately 85 galls on the red raspberry canes from the horticultural "50" patch.

5. Approximately 336 galls on the wild blackberry canes from the railroad track along side of the experimental patch.

The following data show the time, the number, and the kind of Agrilus species as they emerged from the canes in the bell jars.

Sub I.

This bell jar contained raspberry canes from the entomological experimental patch.

Series A. (Beetles).

Emerged March 20, 1933.

Nos.

1. A. communis. 2. A. communis. 3. A. communis.

Emerged March 21, 1933.

Nos.

4.	A.	communis.	12.	A.	communis.	20.	A.	communis.
5.	"	"	13.	"	"	21.	"	"
6.	"	"	14.	"	"	22.	"	"
7.	"	"	15.	"	"	23.	"	"
8.	"	"	16.	"	"	24.	"	"
9.	"	"	17.	"	"	25.	"	"
10.	"	"	18.	"	"			
11.	"	"	19.	"	"			

Sub.I.

Emerged March 22, 1933.

Nos.

26.	A.	communis.	34.	A.	communis.	42.	A.	communis.
27.	"	"	35.	"	"	43.	"	"
28.	"	"	36.	"	"	44.	"	"
29.	"	"	37.	"	"	45.	"	"
30.	"	"	38.	"	"	46.	"	"
31.	"	"	39.	"	"	47.	"	"
32.	"	"	40.	"	"	48.	"	"
33.	"	"	41.	"	"			

Emerged March 23, 1933.

Nos.

48.	A.	communis.	52.	A.	communis.	56.	A.	communis.
49.	"	"	53.	"	"	57.	"	ruficollis.
50.	"	"	54.	"	"			
51.	"	"	55.	"	"			

Emerged March 24, 1933.

Nos.

58. A. communis. 60. A. communis. 62. A. ruficollis.

59. " " 61. " ruficollis. 63. " "

Emerged March 25, 1933.

Nos.

64. A. communis. 66. A. ruficollis. 68. A. ruficollis.

65. " " 67. " "

Emerged March 27, 1933.

Nos.

69. A. communis. 71. A. ruficollis. 73. A. ruficollis.

70. " ruficollis. 72. " " 74. " "

Sub I.

75. A. ruficollis.

76. " "

Emerged March 28, 1933.

Nos.

77. A. communis.

78. " "

Series B. (Parasites).

None emerged.

March 20 three A. communis emerged. March 21 the emergence rate jumped and 22 A. communis emerged. Again on March 22 there were 22 A. communis in the bell jar.

On March 23 the rate of emergence dropped, as only 9 A. communis and A. ruficollis were found. This one specimen of A. ruficollis was the first to make its appearance. Three A. communis and three Agrilus ruficollis were found on March 24. Two A. communis and three A. ruficollis emerged March 25. Only one A. communis emerged March 27, as compared to 7 A. ruficollis. The last beetles emerged March 28, and these were two specimens of A. communis.

There were 19 dead beetles in the canes that crumbled up when touched. Some of them had their head partially sticking out of the exit holes. Both species of Agrilus were represented.

No parasites emerged from this material.

Sub II.

This bell jar had rose canes in it from the Botanical Gardens.

Series A.(Beetles).

Emerged March 21, 1933.	Emerged March 22, 1933.
Nos.	Nos.
1. A. communis.	3. A. communis.
2. " "	4. " "

Emerged March 23, 1933.

Nos.

1. A. communis. 2. A. communis. 3. A. communis.

Sub.III.

Emerged March 24, 1933.

Nos.

4. A. communis. 6. A. communis.

5. " " 7. " "

Emerged March 25, 1933.

Nos.

8. A. communis.

Emerged March 27, 1933.

Nos.

9. A. communis. 12. A. communis. 15. A. ruficollis.

10. " " 13. " "

11. " " 14. " ruficollis.

Emerged March 30, 1933.

Nos.

16. A. communis. 17. A. ruficollis.

Emerged March 31, 1933.

Nos.

18. A. ruficollis.

Series B (Parasites).

Emerged March 21, 1933.

Nos.

1. Braconidae. 2. Braconidae.

On March 23 the first three beetles emerged. They were A. communis. March 24 there were four A. communis that had emerged. The rate fell off March 25, as only one A. communis emerged. On March 27 the rate jumped up again, as five A. communis and two A. ruficollis emerged. The first appearance of an A. ruficollis beetle in this bell jar was four days later than in bell jar Sub I. March 30 only one A. communis and one A. ruficollis emerged. The last beetle to emerge was a single A. ruficollis specimen on March 31.

There were 12 dead beetles in the canes in this bell jar. They were both A. communis and A. ruficollis.

Two parasites emerged on March 21. They were Braconids. These were the only parasites found in the different batches of material.

Sub. IV.

This bell jar had raspberry canes from the horticultural "50" patch.

Series A (Beetles).

Emerged March 27, 1933.

Nos.

1. A. communis. 2. A. ruficollis.

Emerged March 29, 1933.

Nos.

3. A. communis. 4. A. ruficollis.

Emerged March 30, 1933. Emerged April 8, 1933.

Nos. Nos.

5. A. communis. 6. A. communis.

March 27 an A. communis and an A. ruficollis both emerged. The same thing happened on March 29. On March 30 a single A. communis beetle emerged. Then after a lapse of eight days another A. communis beetle emerged on April 8.

There were five dead beetles in the canes and these five consisted of both species of Agrilus.

Series B.(Parasites).

None emerged.

Sub. V.

The material in this bell jar consisted of wild blackberry canes.

Series A.(Beetles).

Emerged March 24, 1933.

Nos.

1. A. ruficollis. 3. A. ruficollis. 5. A. ruficollis.

2. " " 4. " " 6. " "

Emerged March 25, 1933.

Nos.

7. A. ruficollis.

Emerged March 27, 1933.

Nos.

8.	A. ruficollis.	12.	A. ruficollis.	16.	A. ruficollis.
9.	" "	13.	" "	17.	" "
10.	" "	14.	" "	18.	" "
11.	" "	15.	" "	19.	" "

Emerged March 28, 1933.

Nos.

20.	A. ruficollis.	22.	A. ruficollis.	24.	A. ruficollis.
21.	" "	23.	" "		

Emerged March 29, 1933.

Nos.

25. A. ruficollis.

Emerged March 31, 1933.

Nos.

26. A. ruficollis.

Sub. V.

Emerged April 3, 1933.

Nos.

27.	A. ruficollis.	28.	A. ruficollis.	29.	A. ruficollis.

Emerged April 5, 1933.

Nos.

30.	A. ruficollis.	31.	A. ruficollis.	32.	A. ruficollis.

Emerged April 8, 1933.

Nos.

33. A. ruficollis.

The first six specimens of A. ruficollis emerged March 24. Only one A. ruficollis emerged March 25. On March 27 twelve A. ruficollis beetles emerged. March 28 five A. ruficollis beetles were found. On March 29 the rate fell off and only a single A. ruficollis emerged. The same thing happened on March 31. On April 3 three specimens of the same kind emerged. The same thing happened April 5. The last specimen emerged April 8. All the beetles taken from this bell jar were A. ruficollis.

There were 15 dead beetles in the wild blackberry canes in this bell jar.

Series B.(Parasites).

None emerged.

The following data were taken to learn the per cent of emergence of the beetles.

Sub. I.

1. Red Raspberry canes from the experimental patch.

   a. 244 galls.

   b. 78 beetles emerged.

   c. 32 per cent emergence.

Sub. II.

1. Rose canes from the Botanical Gardens.

   a. 70 galls.

   b. 13 beetles emerged.

   c. 19 per cent emergence.

Sub. III.

1. Red raspberry canes from the east horticultural patch.

   a. 96 galls.

   b. 18 beetles emerged.

   c. 19 per cent emergence.

Sub. IV.

1. Red raspberry canes from the horticultural "50" patch.

   a. 85 galls.

   b. 6 beetles emerged.

   c. 7 per cent emergence.

Sub. V.

1. Wild blackberry canes from along the railroad track by the experimental patch.

   a. 336 galls.

   b. 33 beetles emerged.

   c. 10 per cent emergence.

The following measurements were taken in order to learn further the characteristics of the Agrilus species.

Sub. I.

Distance from exit hole to the gall.

1. 18.8mm.	10. 109.4mm.	20. 103.1mm.
2. 43.8mm.	11. 87.5mm.	21. 215.6mm.
3. 3.1mm.	12. 43.8mm.	22. 121.9mm.
4. 115.6mm.	13. 112.5mm.	23. 109.4mm.
5. 31.3mm.	14. 15.6mm.	24. 128.4mm.
6. 68.8mm.	15. 125.0mm.	25. 40.6mm.
7. 109.4mm.	16. 193.8mm.	
8. 3.1mm.	17. 140.6mm.	
9. 40.6mm.	18. 50.0mm.	

The average distance is 82.5mm. This distance was measured from the top of the gall to the nearest edge of the exit hole. The minimum distance is 3.1mm. The maximum distance is 215.6mm.

Length of the tunnel.

1. 18.8mm.	6. 78.1mm.	11. 87.5mm.
2. 43.8mm.	7. 109.4mm.	12. 57.8mm.
3. 3.1mm.	8. 9.4mm.	13. 112.5mm.
4. 134.4mm.	9. 48.4mm.	14. 15.6mm.
5. 39.1mm.	10. 117.2mm.	15. 125.0mm.

16. 218.8mm.	20. 107.8mm.	24. 153.1mm.
17. 146.9mm.	21. 226.6mm.	25. 40.6mm.
18. 50.0mm.	22. 184.8mm.	
19. 35.9mm.	23. 128.1mm.	

The average length of the tunnel is 91.7mm. These measurements on the length of the tunnel were taken from the top of the gall on the inside of the cane, to the end of the tunnel, which in some cases ran beyond the exit hole. The minimum length is 3.1mm. and the maximum is 226.6mm.

Distance the beetle came back down the cane.

1.	10. 7.8mm.	19. 4.7mm.
2.	11. 7.8mm.	20. 4.7mm.
3.	12. 14.1mm.	21. 10.9mm.
4. 18.8mm.	13.	22. 62.5mm.
5. 7.8mm.	14.	23. 18.8mm.
6. 9.4mm.	15.	24. 25.0mm.
7.	16. 25.0mm.	25.
8. 6.3mm.	17. 6.3mm.	
9. 7.8mm.	18.	

This means the distance some of the beetles came back down the cane before emerging. Some of the beetles made their exit hole from the end of the tunnel, while others made a short tunnel back down the cane before

making an exit hole. The average length of this short tunnel down to the exit hole is 15.3mm. The minimum length is 4.7mm. and the maximum is 62.5mm. Both species of Agrilus came back down the tunnel.

The beetles that came back down the tunnel emerged bottom side up.

Size of exit holes (long and short diameters).

Long		Short	Long		Short
1.	2.5mm.	1.5mm.	14.	1.5mm.	1.5mm.
2.	2.0mm.	1.5mm.	15.	2.0mm.	1.5mm.
3.	2.5mm.	1.5mm.	16.	2.0mm.	1.5mm.
4.	2.0mm.	1.5mm.	17.	2.0mm.	1.5mm.
5.	2.0mm.	1.5mm.	18.	2.0mm.	2.0mm.
6.	2.0mm.	1.5mm.	19.	2.0mm.	1.5mm.
7.	2.0mm.	1.5mm.	20.	2.0mm.	1.5mm.
8.	2.0mm.	1.5mm.	21.	2.0mm.	1.5mm.
9.	2.5mm.	1.5mm.	22.	1.5mm.	1.0mm.
10.	2.0mm.	1.5mm.	23.	2.5mm.	1.5mm.
11.	2.0mm.	1.5mm.	24.	2.0mm.	1.5mm.
12.	2.0mm.	1.5mm.	25.	1.5mm.	1.5mm.
13.	2.0mm.	1.5mm.			

The average long diameter of the exit hole is 2mm. and the average short diameter is 1.5mm. The minimum long diameter is 1.5mm. and the maximum long diameter is

is 2.5mm. The minimum short diameter is 1mm, and the maximum short diameter is 2mm.

Sub. II.

Distance from exit hole to the gall.

1.	75.0mm.	4.	15.6mm.	7.	43.8mm.
2.	28.1mm.	5.	15.6mm.	8.	37.5mm.
3.	25.0mm.	6.	37.5mm.	9.	7.8mm.
				10.	14.1mm.

The average distance is 30mm. The minimum is 7.8mm. and the maximum is 75.0mm.

Length of the tunnel.

1.	75.0mm	4.	28.1mm.	7.	53.1mm.
2.	28.1mm.	5.	34.4mm.	8.	40.6mm.
3.	25.0mm.	6.	37.5mm.	9.	7.8mm.
				10.	23.4mm.

The average length of the tunnel is 35.3mm. The minimum is 7.8mm. and the maximum is 75mm.

Distance the beetle came back down the cane.

1.		4.	12.5mm.	7.	9.4mm.
2.		5.	18.8mm.	8.	3.1mm.
3.		6.		9.	
				10.	9.4mm.

The average distance some of the beetles burrowed back down the cane is 10.6mm. The minimum distance is 3.1mm. and the maximum is 18.8mm. The A. communis beetles came back down the tunnel, here. No A. ruficollis. beetles emerged in this bell jar.

Size of exit holes (long and short diameters).

Long		Short	Long		Short
1.	2.0mm.	1.5mm.	6.	2.0mm.	1.5mm.
2.	2.0mm.	1.5mm.	7.	2.0mm.	1.5mm.
3.	2.0mm.	1.5mm.	8.	2.0mm.	1.5mm.
4.	1.5mm.	1.5mm.	9.	1.5mm.	1.0mm.
5.	2.0mm.	1.5mm.	10.	1.5mm.	1.5mm.

The long diameter average is 1.9mm., while the short diameter average is 1.5mm. The minimum long diameter 1.5mm. and the maximum is 2mm. The minimum short diameter is 1mm. and the maximum is 1.5mm.

Sub. III.

Distance from exit hole to the gall.

1.	112.5mm.	6.	143.8mm.	11.	87.5mm.
2.	93.8mm.	7.	162.5mm.	12.	125.0mm.
3.	106.3mm.	8.	131.3mm.	13.	115.6mm.
4.	171.9mm.	9.	121.9mm.	14.	146.9mm.
5.	56.3mm.	10.	121.9mm.	15.	128.1mm.

The average length is 124mm. The minimum length is 56.3mm. and the maximum length is 171.9mm.

Distance the beetle came back down the cane.

1.	34.4mm.	6.		11.	
2.		7.		12.	
3.		8.		13.	
4.		9.	90.6mm.	14.	
5.		10.		15.	31.3mm.

The average distance is 52.1mm. The minimum distance is 31.3mm. and the maximum is 90.6mm. Both species came back down the tunnel. Those that did come back down emerged upside down.

Size of exit holes (long and short diameters).

Long		Short	Long		Short
1.	2.0mm.	1.5mm.	9.	1.5mm.	1.0mm.
2.	2.0mm.	1.5mm.	10.	2.0mm.	1.5mm.
3.	2.5mm.	1.5mm.	11.	2.0mm.	1.5mm.
4.	2.0mm.	1.5mm.	12.	2.0mm.	1.5mm.
5.	2.0mm.	1.5mm.	13.	1.5mm.	1.5mm.
6.	1.5mm.	1.5mm.	14.	2.0mm.	1.5mm.
7.	2.0mm.	1.5mm.	15.	2.0mm.	1.5mm.
8.	2.0mm.	1.5mm.			

The average length of the long diameter is 1.9mm. and the average length of the short diameter is 1.5mm. The minimum length of the long diameter is 1.5mm. and the maximum is 2.5mm. The short diameter has a minimum length of 1mm. and a maximum of 1.5mm.

Sub. IV.

Distance from exit hole to the gall.

1. 46.9mm. 3. 81.3mm. 5. 31.3mm.

2. 121.9mm. 4. 12.5mm. 6. 106.3mm.

The length averages 66.7mm. The minimum is 12.5mm. and the maximum is 121.9mm.

Length of the tunnel.

1. 60.9mm. 3. 81.3mm. 5. 40.6mm.

2. 121.9mm. 4. 12.5mm. 6. 106.3mm.

The average length of the tunnel is 70.6mm. The minimum length is 12.5mm. The maximum length is 121.9mm.

Distance the beetle came back down the cane.

1. 14.1mm. 3. 5. 9.4mm.

2. 4. 6.

The average distance is 11.8mm. The minimum is 9.4mm. and the maximum is 14.1mm. Both an A. ruficollis and an A. communis were observed coming back down the cane, and they emerged upside down.

Size of exit holes (long and short diameters).

Long		Short	Long		Short
1.	2.0mm.	1.5mm.	4.	2.0mm.	1.5mm.
2.	2.5mm.	1.5mm.	5.	2.0mm.	1.5mm.
3.	2.0mm.	1.5mm.	6.	2.0mm.	2.0mm.

The average long diameter is 2.1mm. and the average short diameter is 1.6mm. The minimum long diameter is 2mm. and the maximum is 2.5mm. The short diameter has a minimum of 1.5mm. and a maximum of 2mm.

Sub. V.

Distance from exit hole to the gall.

1. 118.8mm.	10. 62.5mm.	19. 12.5mm.
2. 51.6mm.	11. 18.8mm.	20. 87.5mm.
3. 75.0mm.	12. 6.3mm.	21. 43.8mm.
4. 12.5mm.	13. 43.8mm.	22. 62.5mm.
5. 46.9mm.	14. 65.6mm.	23. 34.4mm.
6. 115.6mm.	15. 15.6mm.	24. 87.5mm.
7. 21.9mm.	16. 34.4mm.	25. 50.0mm.
8. 93.8mm.	17. 43.8mm.	
9. 12.5mm.	18. 96.9mm.	

The average distance is 52.6mm. The minimum is 6.3mm. and the maximum is 118.8mm.

Length of the tunnel.

1. 118.8mm.	6. 115.6mm.	11. 68.8mm.
2. 71.9mm.	7. 59.4mm.	12. 46.9mm.
3. 75.0mm.	8. 104.7mm.	13. 43.8mm.
4. 57.8mm.	9. 31.3mm.	14. 90.6mm.
5.0 46.9mm.	10. 84.4mm.	15. 15.6mm.

16.	34.4mm.	20.	87.5mm.	24.	87.5mm.
17.	43.8mm.	21.	43.8mm.	25.	57.8mm.
18.	96.9mm.	22.	62.5mm.		
19.	35.9mm.	23.	34.4mm.		

The average length is 64.6mm. The minimum is 15.6mm. The maximum is 118.8mm.

Distance the beetle came back down the cane.

1.		10.	21.9mm.	18.	
2.	20.3mm.	11.	50.0mm.	19.	23.4mm.
3.		12.	40.6mm.	20.	
4.	45.3mm.	13.		21.	
5.		14.	25.0mm.	23.	
6.		15.		24.	
7.	37.5mm.	16.		25.	23.4mm.
8.	10.9mm.	17.			

The average distance here is 28.8mm. The minimum is 10.9mm. and the maximum is 50mm. Only A. ruficollis emerged here. They came back down the tunnel in some cases, and emerged upside down.

Size of exit holes (long and short diameters).

Long		Short	Long		Short
1.	2.0mm.	1.5mm.	3.	2.5mm.	1.5mm.
2.	2.0mm.	1.5mm.	4.	2.5mm.	1.5mm.

	Long	Short		Long	Short
5.	1.5mm.	1.0mm.	17.	2.5mm.	1.5mm.
6.	2.0mm.	1.5mm.	18.	2.0mm.	1.5mm.
7.	2.0mm.	1.5mm.	19.	2.0mm.	1.5mm.
8.	2.0mm.	1.5mm.	20.	2.0mm.	1.5mm.
9.	2.0mm.	1.5mm.	21.	2.5mm.	1.5mm.
10.	2.0mm.	1.5mm.	22.	2.0mm.	1.5mm.
11.	2.5mm.	1.5mm.	23.	2.0mm.	1.5mm.
12.	2.0mm.	1.5mm.	24.	2.0mm.	1.5mm.
13.	2.0mm.	1.5mm.	25.	1.5mm.	1.5mm.
14.	2.5mm.	1.5mm.			
15.	1.5mm.	1.5mm.			
16.	2.0mm.	1.5mm.			

The average long diameter is 2mm. and the average short one is 1.5mm. The long diameter has a minimum of 1.5mm. and a maximum of 2.5mm. The minimum short diameter is 1mm. and the maximum is 1.5mm.

General Discussion.

In the entomological experimental patch there is an average of eighty-eight canes per plot. In the horticultural "50" patch this average is a little lower, as there are approximately seventy-six canes per plot. The east horticultural patch can not be accurately compared with the experimental patch or the horticultural "50" patch as to average number of canes, because the canes are planted in hills. The average per hill is approximately twenty canes.

The average number of infested canes per plot in the experimental patch is about thirty-two, in round numbers. This compares exactly with the average in the horticultural "50" patch, as it also has thirty-two infested canes. The east horticultural patch has an average of about six canes per hill.

The experimental patch has an average infestation of 36 per cent. This is not as high as the infestation in the horticultural "50" patch, as it has 42 per cent. The lowest per cent of infestation is in the east horticultural patch, it being 30 per cent. This is peculiar in that the 36 per cent infestation of the experimental patch is equally distant from the 42 per cent infestation of the horticultural "50" patch and from the 30 per cent infestation of

the east horticultural patch.

There is an average of twenty-two broken canes per plot in the experimental patch. The average for the horticultural "50 patch is somewhat lower, with nineteen broken canes. The east horticultural patch has an average of four broken canes per hill.

The experimental patch has an average of about 70 per cent broken canes. The horticultural "50" patch is considerably lower in that it has an average breakage of about 59 per cent. The east horticultural patch compares more favorably with the experimental patch, as it has an average of approximately 65 per cent broken canes.

The raspberry canes in Sub I are from the entomological experimental patch. Seventy-eight beetles were taken from the raspberry canes in Sub I. Of these seventy-eight only fourteen of them were A. ruficollis. The other sixty-four were A. communis. This was verified by sending several specimens to Washington D. C. They were described as Agrilus communis ab. rubicola Abeille de Perrin, by W. S. Fisher, Associate Entomologist in the Bureau of Entomology at Washington D. C. No parasites emerged from this material.

Rose canes in Sub II are from the Botanical Gardens. Thirteen beetles were taken from the rose canes in Sub II.

These were all A. communis. No parasites emerged from this material, either.

Sub III contains raspberry canes from the east horticultural patch. Eighteen specimens emerged from this material. Of these eighteen beetles, four were A. ruficollis and the remaining fourteen were A. communis. Two parasites emerged from this material. They were Braconids.

Raspberry canes from the horticultural "50" patch were put in Sub IV. Four A. communis and two A. ruficollis emerged. No parasites were found.

Wild blackberry canes from along the railroad track by the experimental patch, were put in Sub V. Thirty-three beetles emerged and they were all A. ruficollis. Not a single specimen of A. communis was found. A. communis has not been bred from black berry canes, as yet. No parasites emerged.

About sixty beetles were found dead in the canes. Some had their heads sticking part way out of the exit hole, while others had no head at all. The specimens all crumbled up when touched. Either the beetles were too weak to burrow their way entirely out of the thicker canes, or there is some disease that kills them off.

The per cent of emergence in Sub I is approximately 32 per cent. In Sub II it is 19 per cent. Sub III has a

19 per cent emergence also. In Sub IV it is only 7 per cent. Sub V has a low per cent, it being about 10.

There is a considerable variation in the distance from the exit hole to the gall. Sub I has an average distance of 82.5mm. Sub II averages 30mm. Sub III has an average of 113.6mm. The average for Sub IV is 66.7mm. The average is 52.6mm. for Sub V. Adding the averages of Subs I, III, and IV gives an average of 87.6mm. for all the raspberry material. In the raspberry material of Sub I the average distance from the exit hole to the gall is very close to the average of Subs I, III, and IV.

Measurements were taken on the actual length of some of the tunnels. The average for Sub I is 91.7mm., for Sub II it is 35.3mm., for Sub III it is 124mm., for Sub IV it is 70.6mm., and for Sub V it is 64.6mm. The averages of Subs I, III, and IV average 95.4mm. for the length of the tunnels in all the raspberry material. Again, the average of Sub I is very near the average of Subs I, III, and IV.

Some of the beetles turned around and tunneled back down the pith before emerging. Both species of Agrilus did this. When they emerged, after coming back down the pith, they did it upside down. Not only were the flat or short diameters on the bottom part of the exit holes, but some of the beetles were actually observed upside down.

This was done by splitting a few canes open that had beetles all read to emerge. In the material in Sub I the average distance down is 16.4mm. In Sub II it is 10.6mm. Sub III has an average distance of 52.1mm. for the highest average. Sub IV averages 11.8mm. The average is 28.8mm. in Sub V. Subs I, III, and IV average 26.8mm. for all the raspberry material gathered.

Two averages were taken on the size of the exit holes. They were the long and short diameter measurements. The material in Sub I has a long diameter average of 2mm. and a short on of 1.5mm. The diameter averages are the same for the material in Subs II and III, as the long diameters average 1.9mm. and the short ones average 1.5mm. The largest average diameter, both long and short, is found in the material of Sub IV. This is 2.1mm. for the average long diameter and 1.6mm. for the average short diameter. Sub V has an average of 2mm. for the long diameter and 1.5 for the short one. These figures are the same as those found in Sub I.

There is an apparently larger infestation of raspberries by A. communis than by A. ruficollis. This is shown by the emergence records of Subs I, III, and IV. In Sub I the rate of emergence of A. communis to A. ruficollis is 4.6 to 1. In Sub III it is 3.5 to 1. Sub IV has a rate of 2 to 1. The average rate of emergence of

the three batches of material is 3.4 to 1.

SUMMARY.

1. A. communis infests Michigan raspberries as does A. ruficollis. In fact A. communis is more prevalent on raspberries. The ratio, as determined by three patches around East Lansing, is 3.4 to 1.
2. The total infestation of Michigan raspberry patches may run anywhere from 30 to 42 per cent.
3. More than half of the infested canes break off. The per cent varies anywhere from 59 to 70.
4. There may be some disease that kills the adults as they are about to emerge. Many dead beetles were found in the canes. The thickness of the canes may prevent some of the beetles from emerging, however.
5. The per cent of emergence of both Agrilus species from raspberry canes varies anywhere from 7 to 32 per cent.

From rose canes it is about 19 per cent, as determined by rose material taken from the Botanical Gardens. It is about 10 per cent for wild blackberry canes taken from around the entomological experimental patch. Two parasites emerged from bell jar Sub III.

6. The average distance of the exit hole from the gall is 87.6mm. in the raspberry material. It is 30mm in the rose material and 52.6mm. in the wild blackberry material.

7. The average length of the tunnel in the raspberry material is 95.4mm. In the rose it is 35.3mm. and in the wild blackberry it is 64.6mm.

8. Both A. ruficollis and A. communis may turn around in the pith of the cane and tunnel a short distance downward before emerging. The average length of this tunnel is 26.8mm. in the raspberry, 10.6mm. in the rose, and 28.8mm. in the wild blackberry. When a beetle tunnels down the cane it emerges upside down.

9. The long and short diameters of the exit holes vary but a little bit. The average long diameter of the exit hole in raspberry canes is 2mm. and the average short diameter is 1.5mm. The average long diameter in the rose canes is 1.9mm. and the short one is 1.5mm. The average diameters in the wild blackberry canes are 2mm. and 1.5mm., respectively.

10. A. ruficollis seldom infests rose bushes.

11. A. communis does not appear to infest wild blackberry canes.