BIOLOGY AND CONTROL

OF STICTOCEPHALA INERMIS (FAB.)

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By

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PREFACE

Grateful acknowledgement is given to Dr. F. A. Fenton under whose direction and supervision this paper was prepared.

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TABLE OF CONTENTS

INTRODUCTION

During the summer and fall of 1938, a number of American elms (Ulmus americana L.) and Asiatic elms (U. pumila L.) were found to have been apparently severely damaged from oviposition by a species of tree hopper. These elms had been planted along a nine-mile strip of road south of Stillwater, Oklahoma, on Highway 40 by the State Highway Commission as a part of a highway beautification program. The discovery of this infestation offered an opportunity for developing a control and for studying the biology of the tree hopper responsible for the injury. A thorough search of the literature proved that control experiments pertaining to tree hoppers were scanty in nature with no research having been done on species infesting elms. The studies were begun early in the fall of 1938 and continued throughout May, 1939. They consisted of spraying experiments, studies on the nature and extent of the injury and notes on the biology of the tree hopper which was identified as Stictocephala inermis (Fab.)[1] (Fig. 1)

REVIEW OF LITERATURE

Distribution and Synonymy

Stictocephala inermis (Fab.), commonly known as the green clover tree hopper, is one of the most common of all the tree hoppers. It has been collected in Tillman, Grady, Canadian, Payne, Pontotoc, Latimer, LeFlore, and Choctaw Counties in Oklahoma and probably occurs throughout the State. Jones (10) lists this species as occurring in Nebraska. Yothers (20, 21) studied S. inermis in the State of Washington and finds it the most common tree hopper species in the Pacific north-

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1 Determined by P. B. Lawson

Fig. 1A. Lateral view of adult green clover tree hopper, Stictocephala inermis. (Enlarged 10 times)

1B. Dorsal view of adult green clover tree hopper, Stictocephala inermis. (Enlarged 10 times)

A

B

west. Hodgkiss (8) lists this species in New York. This insect is present generally throughout most of the United States with the exception of the southeast.

This species was originally described by Fabricius (2, p. 677) and placed in his genus Membracis in 1775. In 1830, Say (14, p. 243) described it as goniphora of the same genus. Fitch, in 1851, (5, p. 48) referred inermis Fab. to the genus Smilia of Germar. Walker (18, p. 1141) in 1852, placed Say's species in the genus Ceresa of Amyst and Serville. In 1869, Stal (16, p. 246) placed inermis in his new genus Stictocephala. Rathvon (13, p. 551) in the same year used the same specific determination but placed it in Germar's Smilia (misspelled as Smillia). Since Uhler (17, p. 471), in 1871, placed the species back in the genus Stictocephala of Stal (spelling it as Stictocephalus) it has retained that classification. (21)

Injury

Goodwin and Fenton (6) reported injury to apple trees caused by the oviposition punctures of Ceresa bubalus (Fab.) primarily as an unnatural sloughing off of the woody growth of apple twigs and secondarily by allowing ingress of phytopathogens.

Biology

Yothers (21) found that the eggs of S. inermis hatched during April and early May and that an average of 68 days was required for the nymphs to pass through five instars and reach maturity. He also found a natural egg mortality of 11.7 per cent.

Control

Lovett (11) suggested the use of eight gallons of a heavy miscible oil to 100 gallons of water as a tree hopper ovicide, but seemed somewhat dubious as to the ability of the oil to penetrate through the outside bark and reach the egg masses within. Yothers (20, 21) sprayed the eggs of S. inermis with a four per cent oil emulsion or miscible oil and achieved satisfactory results. Sorenson (15) indicates that a dormant miscible oil spray such as used in the control of

Aspidiotus perniciosus Comstock is an important measure in the control of tree hoppers. Hudson (9), while working with Glossonatus crataegi Fitch, found dormant egg sprays ineffective, but control was obtained by a contact spray of oil-nicotine against the nymphs. Harmon (7) found that using a dormant lubricating oil emulsion of six per cent strength would give a good control of Glossonatus crataegi Fitch.

As a natural means of control, Wildermuth (19) records several species of birds feeding of S. festina Say. He also records toads as being predators of S. festina Say. According to Yothers (21) two coccinellids; namely, Adelia bipunctata (L.) and Hyperaspis quadrivittata Lec. and several species of spiders and ants were found feeding on emerging nymphs.

As a cultural means of control, Sorenson (15) regards clean culture as a major factor for controlling tree hoppers, and Yothers (21) considers clean culture as a last resort in cases of severe injury where the use of oil sprays is undesirable.

BIONOMICS

Life history studies by Yothers of the green clover tree hopper had been carried on in the Pacific Northwest where it is a pest of fruit trees. In this locality the tree hopper hibernates in the bark of fruit trees in the egg stage. The eggs hatch in early spring, the nymphs mature by early summer, and the adults lay their eggs during the middle and latter part of the summer. There is only one generation a year.

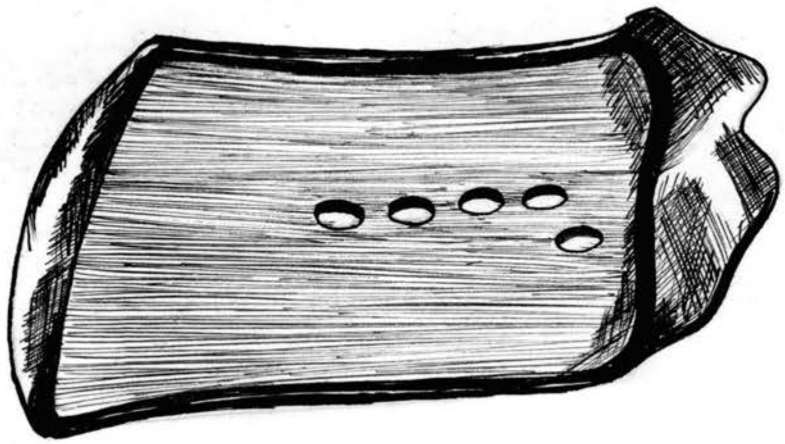
Life History Technique

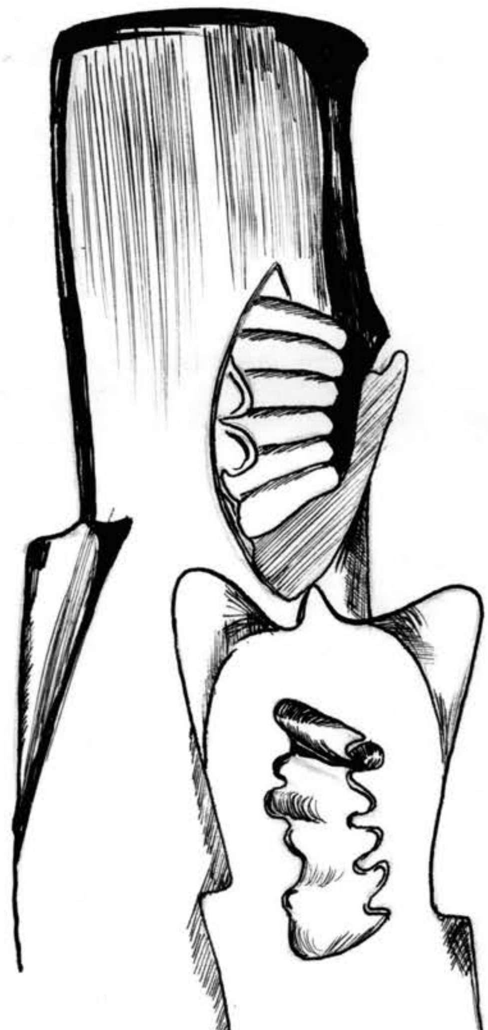
Life history studies of S. inermis were carried out at Stillwater in a normal air temperature room. Infested twigs were placed in a four-ounce bottle with the cut ends extending into the neck of the bottle; the bottle was filled with water-saturated moss. Surrounding the bottle were the summer host test plants growing in the same soil types as found in their natural habitat. After the nymphs emerged and fell to the ground they attached themselves to a succulent host plant and remained on the plant until the adult stage. After the nymphal host plant selection had taken place, wire cages were placed over the plant so that no new reinfestation could occur. In this manner, host preference in the laboratory was determined, and a general life cycle was observed.

Egg Deposition

The green clover tree hopper lays its eggs in two-three and-four-year old wood of American and Asiatic elm. The eggs are laid in the lower branches and may be in single, widely separated pouches, or the pouches may be located in close proximity to each other. Egg pouches are normally located on the dorsal surface of the twig. The oviposition scar is a small longitudinal, crescent-shaped slit into and sometimes through the bark where the female deposits from one to nine eggs in pouch-like cases, (Fig. 2). In 3,633 egg pouches examined in Asiatic elm, 18,228 eggs were found giving an average of 5.02 eggs per pouch. In 3,451 egg pouches examined in American elm, 20,174 eggs were found giving an average of 5.85 eggs per pouch. In both the American and Asiatic species, oviposition scars were quite numerous with no noticeable difference in infestation between the two species of elm. Since the elm trees were located on a long stretch of road with variations in the size of trees, examinations were made

Fig. 2 - Eggs of S. inermis in their natural position in the bark.





to see if there were areas of higher or lower resistance to tree hopper injury, but little difference was noted as to oviposition. There was no difference in infestation between the north and south side of either species of elm.

Hatching Period

In common with other tree hoppers, S. inermis overwinters in the egg stage, in either American or Asiatic elm, the eggs normally hatching in the early spring. At Stillwater, the first nymphs emerged April 15. (Table 1)

Table 1 - Emergence of Nymphs from American and Asiatic Elm Twigs

Date	Kind of elm	Number of eggs counted	Percent Hatched
April 19	American	867	39.9
April 19	Asiatic	751	48.0
April 24	American	608	44.4
April 28	American	777	72.2
May 18	American	824	76.3
May 18	Asiatic	776	70.1

Soon after emergence takes place, the first instar nymphs fall to the ground and feed on succulent herbaceous plants. The immature insect seeks the lower level of the host plant and remains there until full grown. In some cases, the nymphs will wander about the main stem of the plant, but a slight jarring of the plant will easily loosen any stage of the nymphs, and they fall to the ground where they immediately hide around the base of the stem. As many as eight nymphs were observed on one host plant in the field.

Summer Host Plants

The nymphs were found almost exclusively on Psoralea tenuiflora var. floribunda (Nutt.) Rydb, and as stated previously in the earlier stages, they were invariably found at the base of the plant. In the laboratory nymphs were reared successfully on false dandelion (Pyrrhopappus sp. D.C.) and wild lettuce (Lactuca scariola L.). They would not feed on Hordeum pusillum Nutt. In the field, nymphs occasionally were found on false dandelion. In no instance was a nymph found feeding on the twigs or leaves of either the American or Asiatic elm.

Transformation to the Adult Stage

In the laboratory, the first adult was found June 6, and thereafter until June 29 a constant adult emergence occurred. It is quite possible that a little earlier emergence took place in the field with regard to both nymph and adult. Fig. 1 illustrates the appearance of Stictocephala inermis in the adult stage.

INJURY

Description

The damage done by the tree hoppers is not in the feeding of the nymph, but by the female in the process of egg laying. With her saw-like ovipositor she cuts through the bark, cambium layer, and into the outer wood giving the stem a roughened appearance, (Fig. 3). Since the oviposition cuts into the cambium layer, it causes the curled fragments of the bark surrounding the puncture to wither and die leaving the infested stem with a knotty appearance; this aspect is due chiefly to the hypertrophied growth of cells surrounding the egg mass. Fig. 3A shows the branch of an American elm with numerous punctures which deform the branch, and Fig. 3B is a typical infested twig of an Asiatic elm, also showing the roughened appearance.

Effect of Oviposition on Tree Growth

Histological study:- In order to determine how deep the incisions were made into the twig, microtome sections were made of twigs of both species of elm. A sliding microtome was used for dissection and sections 20 microns thick were cut. Technique in cutting and staining is a modification of the one used by Langdon (11), and Goodwin and Fenton (6), in that to demineralize the stems required a longer period, 90 days, than that used by Langdon; Goodwin and Fenton counterstained the safranin with haemotoxyln solution, whereas no counter stain was necessary in this case, since the apparent injury was all that was required.

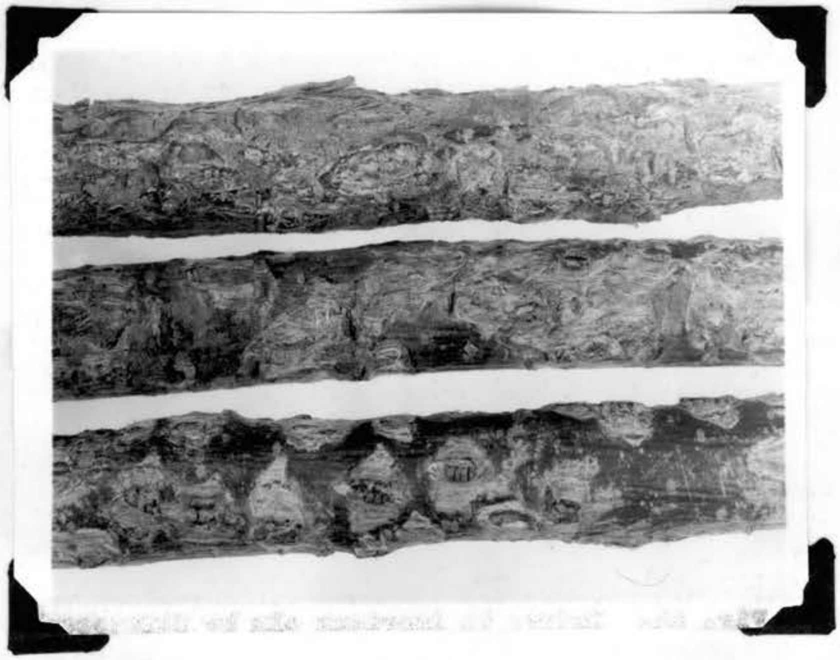
In examining the injury caused by the tree hopper's oviposition, (Fig. 4), one can perceive that it may result in the food supply being cut off if the injury is sufficiently heavy; and it may be a means by which a plant pathogen may enter the healthy tissue causing rotting or any other unhealthy condition.

Fig. 5 pictures an infested and a non-infested Asiatic elm tree showing the dead tips of the infested tree as compared to the normal leafing of the healthy tree.

Diameter measurements:- Since it is the habit of S. inermis to oviposit in two-three and-four-year old twigs of American and Asiatic elms, and since its oviposition may cause a consequent decrease in the growth of infested over non-infested twigs, a series

Fig. 3A. Injury to American elm by <u>Stictocephala inermis</u> showing characteristic roughened shaggy appearance of bark caused by oviposition punctures. (natural size)

3B. Injury to Asiatic elm by <u>Stictocephala inermis</u> showing characteristic roughened shaggy appearance of bark caused by oviposition punctures. (natural size)

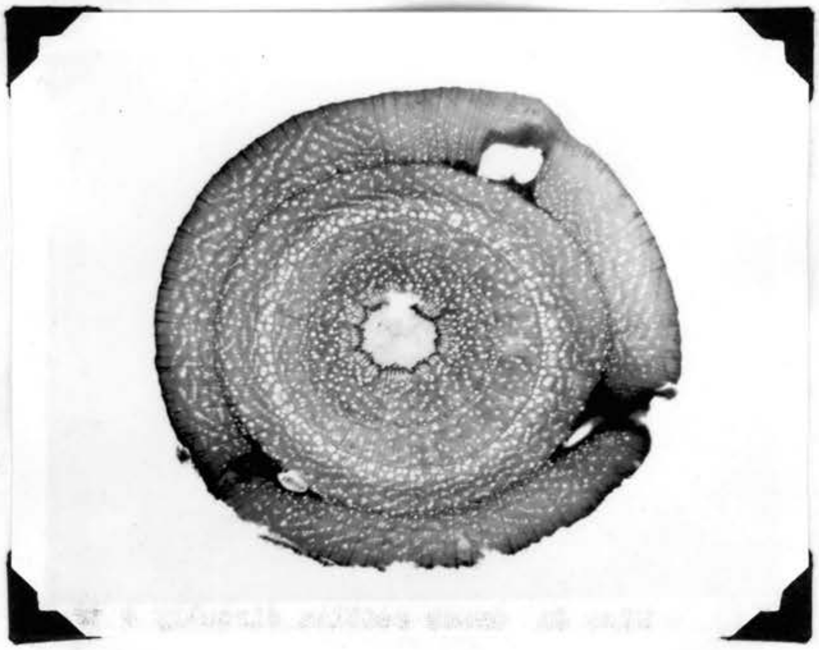


A

B

Fig. 4A Cross section directly over oviposition scar of an American elm twig showing damage to normal tissues caused by _Stictocephala inermis_ in the process of egg laying. (Enlarged 11 times)

4B Cross section of an Asiatic elm twig at far end of oviposition scar showing damage to normal tissues caused by _Stictocephala inermis_ in the process of egg laying. (Enlarged 11 times)



A

B

Fig. 5A. Uninfested Asiatic elm showing tree in full leaf with no apparent dead tip injury. (natural size)

5B. Infested Asiatic elm showing dead tips of small branches where oviposition scars of *Stictocephala inermis* were unusually heavy. (natural size)

A

B

of measurements were made April 22, 1939, and again September 2, 1939 to determine the growth difference between the infested and non-infested twigs during the growing season of 1939. The instruments used for measuring consisted of a pair of calipers and a millimeter scale. Twenty trees from four to six years of age were used for each set of measurements, there being four sets, the infested American elms, the non-infested American elms, the infested Asiatic elms, and the non-infested Asiatic elms.

The trees were selected and mapped in a field notebook so that the fall measurements could be taken on the same twigs as the spring measurements. To ascertain what constituted an infested tree, the number of oviposition scars on a six-inch branch was counted, and if there were more than 20 scars found, the tree was selected and twig measurements were made. In making the measurements, the following procedure was adopted: (1) Twigs were measured six inches from their point of origin. (2) Ten such twigs were measured from each tree giving a total of 200 measurements for each series. (3) These measurements were taken on sprayed and unsprayed American and Asiatic elm trees.

The mean growth for the infested American elm twigs was calculated by finding the difference between the plus and minus growths of spring and fall, and dividing this difference by the number of samples (200). It was found to be 0.50 mm. in diameter. The mean growth for the non-infested American elm twigs was calculated as above, and found to be 0.42 mm.; the mean difference was thus 0.08 mm. This mean difference was subjected to statistical analysis, and the T value of 0.280 was secured. This value is to be compared to the tabular value, at the five per cent level, 1.966.

The value of T is too small to be considered significant; consequently, the same may be said for the mean difference; namely, 0.08 mm.

The mean growth for the infested Asiatic elm twigs calculated by the method as described above was found to be 0.35 mm. in diameter. The mean growth for the non-infested Asiatic elm twigs was calculated 0.34 mm.; the mean difference was 0.01 mm. The mean difference was subjected to statistical analysis, and is too small to be considered significant.

Conclusions:- By statistical analysis, therefore, there was no difference in the growth diameter between the infested and non-infested American elms and Asiatic elms. General observations show the same condition to be true. In examining the sectioned stems, however, and observing the infested trees, one may conclude that in later years the damage might become more noticeable.

NATURAL CONTROL

A total of 3,891 eggs of S. inermis was counted on the check trees of American elm, of which 3,159 were found alive or hatched, 14 parasitized, and 718 dead, giving a natural egg mortality of 18.45 per cent. The Asiatic elms showed a higher natural egg mortality. Of the 3,206 eggs examined in the check trees, 2,217 were found alive or hatched, 51 were parasitized and 938 were dead, giving a natural egg mortality of 29.26 per cent. It appears that although there is a high infestation of tree hopper eggs in Asiatic elm, this species of tree shows a certain amount of resistance in developing a woody growth between the egg pouches and the outside of the twig. This inhibits the natural hatching of the eggs and creates a barrier which hampers the emergence of the young tree hopper, thereby increasing the natural mortality.

One species of hymenopterous parasite; namely, Polynema striaticorne Gir.[2] was taken from the eggs of S. inermis in both American and Asiatic elm. This insect was not sufficiently abundant to destroy many eggs. Of 20,174 eggs examined in American elm, 104 or 0.52 per cent contained parasites; of the 18,228 eggs examined in Asiatic elm, 254 or 1.39 per cent contained parasites.

SPRAYING EXPERIMENTS

The chemical measures employed to kill tree hoppers may be classed in two general divisions: (1) those used for nymphal control, and (2) those used as ovicides. Each of these measures will to some extent control a tree hopper infestation. Under most conditions, however, an ovicide is the most appropriate and practical measure. Ovicides, consequently, were tested as a means of control for Stictocephala inermis infesting American and Asiatic elms at Stillwater, Oklahoma.

Since oils are used as ovicides for many insects, and since it had been suggested by other authors that oil sprays be used as ovicides to control tree hoppers, two miscible dormant oils were tested as possible controls for S. inermis.

Insecticides Used

The materials purchased represented two oils; namely, "Dendrol" containing approximately 93 per cent actual oil, and "Spra-mulsion" containing approximately 85 per cent actual oil.[(4)] Lime sulphur was

2 Determined by G. A. Gahan

also used, and was diluted in the spray from a 33 degree Baumé concentrate to a five and four degree Baumé spray. These three materials were used in three different time applications of spray. In addition to these substances, the third spray application also included a two per cent "Spra-mulsion" oil plus three percentages of dilutions of dinitro-o-cyclohexylphenol obtained from the Dow Chemical Company as a fusion mix containing 40 per cent of dinitro-o-cyclohexylphenol. The lime sulphur was calculated to the correct Baumé degree strength by the use of a Baumé hydrometer. The DNO (dinitro-ocyclohexylphenol) dilution was calculated in weight. For example, if a 0.1 per cent DNO was needed and one had a 100 per cent toxicant, one would require 0.0083 pounds of 100 per cent DNO to make a 0.1 per cent spray, since water weighs about 8.3 pounds to the gallon.

Spraying Technique

The spray technique consisted of two men operating a wheelbarrow spray arrangement capable of producing 150 pounds pressure; one man pumping, and the other man operating the nozzle. Duplicate trees were sprayed with each type and percentage of oil, and other spray materials. Spraying was done with the highest pressure available with such an outfit.

Both the infested American and Asiatic elms were sprayed in duplicate with each ovicide. Three spray applications were made at different periods; namely, December 4, 1938, referred to as the early winter spray; March 3, 1939, called the late winter spray; and March 22, 1939, referred to as the delayed dormant spray. The quantity of spray applied on each tree varied with the size of the tree sprayed. All of the trees were sprayed until the spray material began to drop from the twigs.

Method of Determining Control

Since the eggs of S. inermis are inserted into and sometimes beneath the bark of the American and Asiatic elm trees, a dissecting knife was used to peel off the abnormal growth from over the egg pouch to enable examination to take place. Live eggs which were turgid and a greyish white in color could be easily separated from those which were killed by the ovicide since the dead eggs were shriveled, had turned a blackish grey, and had become completely deflated. The effectiveness of each treatment was determined from Abbott's formula, (1), which takes natural mortality into consideration. The term "egg control" as used in this thesis means the egg mortality caused by the spray treatment after the effects of natural mortality had been evaluated.

Meteorological Data

Table 2 gives the humidity and temperature records at the time of spraying. These readings, when compared to those following the date of spraying (Table 4), show little variation with regard to either temperature or humidity fluctuations. When Table 2 is compared to Table 3, which gives the mean temperature and rainfall for the last half of 1938 and the first half of 1939, little difference is noted between the mean records of temperature and humidity, and the climatological data present at the time of spraying. Thus, normal weather conditions prevailed at the time of spraying which consequently did not effect the application of the ovicides used.

Effect of Oil Sprays on Leafing

Oils may have varying effects on the early bud development of trees. In some cases they may retard normal development for a brief

Table 2 - Meteorological Factors at Time of Spraying

Spray	Temperature Beginning	Temperature Ending	Humidity Beginning	Humidity Ending	Wind* M.P.H.	Sky Conditions
1st Spray (Early winter) December 4, 1939	49°	58°	43%	24%	15	Fair, Sun shining
2nd Spray (Mid-winter) March 3, 1939	59°	61°	58%	50%	14	Fair, Sun shining
3rd Spray (Late winter) March 22, 1939	66°	65°	41%	30%	5	Fair, Sun shining

*Estimated

Table 3 - Mean Temperature and Rainfall Chart

Year	Month	Mean temperature degrees F.	Mean rainfall inches
1938	July	82.2	3.88
	August	83.4	4.39
	September	74.8	2.16
	October	68.2	0.37
	November	48.6	2.60
	December	40.6	0.42
1939	January	43.4	3.42
	February	37.2	0.61
	March	53.8	1.09
	April	59.8	3.64
	May	70.6	2.99
	June	78.0	4.23

Table 4 - Humidity and Temperature Records for 10 Days Following Each Spray Application

Date	Humidity		Temperature	
December, 1938	7:00 A.M.	7:00 P.M.	High	Low
4	29	30	60	40
5	34	31	58	30
6	49	40	57	36
7	44	44	60	32
8	44	44	58	35
9	59	38	58	22
10	50	49	58	42
11	56	54	50	32
12	57	41	44	33
13	57	56	41	21
14	62	50	53	16
March				
4	64	63	71	48
5	69	63	61	35
6	64	28	61	28
7	53	33	60	33
8	55	36	81	36
9	55	62	70	47
10	71	73	75	47
11	75	32	70	51
12	43	36	65	34
13	52	26	78	35
March				
23	59	47	78	54
24	62	59	79	57
25	68	69	75	53
26	71	67	75	42
27	71	72	68	46
28	73	74	67	38
29	74	74	45	37
30	74	73	64	31
31	73	47	75	42
April 1	59	40	77	43

period as reported by Farrar and Kelly (3), while in others they may not affect the physiology of the plant in any noticeable manner. With these thoughts in mind, leaf counts were made on trees that had been sprayed with winter miscible oils for the control of S. inermis. Both American and Asiatic elms were taken into consideration to note the effect of the winter oils on early leaf development. Counts were made April 19, 1939. Early observations of the elm trees concerned were begun the first week in March to note the first leaf opening. March 20, buds of the Asiatic elm trees showed green, and this date is considered as the first leaf opening of Asiatic elm in the vicinity of Stillwater, Oklahoma. On the whole, American elm trees were decidedly later in first leaf opening. Records show April 6 to be the first leaf opening date for American elms. On Asiatic elm 30 days had elapsed between the time the buds showed green and the counts were made, and 14 days had passed between leaf opening and leaf counts on the American species.

The method of making counts was to select various branches on sprayed trees and check trees. Five branches were selected on each tree, and the number of leaves counted that had developed from one bud on each branch. The average number of leaves from one bud was then determined and recorded. Fig. 6 shows the average number of leaves that had developed from buds sprayed with three different applications of oil sprays. These were counted April 19 when practically all of the trees were beginning to leaf out. Thirteen trees were used which had been sprayed December 4, 1938, 15 trees sprayed March 3, 1939, 19 trees sprayed March 22, 1939, and 10 trees from the checks.

The American elm shows a slight increase in the number of leaves developed from trees sprayed March 22 as compared with the number de-

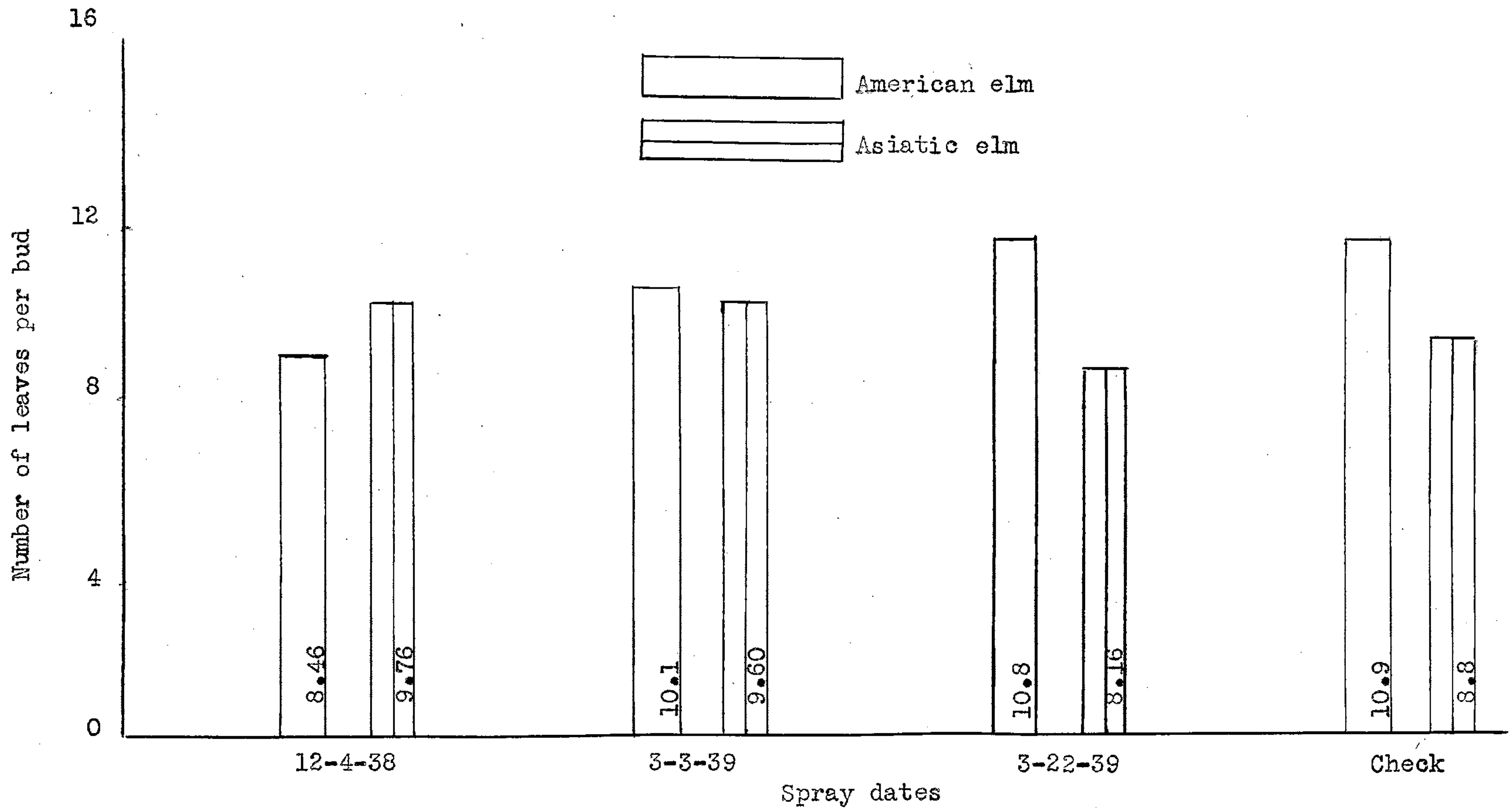


Fig. 6 - Effect of spraying with winter miscible oils on the average number of leaves that opened on American and Asiatic elm trees, April 19, 1949.

veloped from trees sprayed December 4. The difference of 2.34 leaves per bud does not seem to be sufficiently great to be significant considering such varying factors as soil heterogeneity and climatic differences. There was practically no difference in the number of leaves developed in the check trees and those sprayed March 22, a greater number of 0.1 leaf per bud developing in the check.

The Asiatic elms exhibited an opposite reaction from the American elms by having a greater number of leaves develop from the trees sprayed on December 4 than from trees sprayed March 22. This difference of 1.66 leaves per bud does not seem to be significant since the factors mentioned as influencing tree foliation on the American elms would likewise effect the Asiatic elms. The check trees of the Asiatic elm show a slight increase of 0.64 leaf per bud over the trees sprayed March 22, but a decrease of 0.8 leaf and 0.96 leaf per bud under the trees sprayed March 3 and December 4, respectively. This variability may be due chiefly to uncontrolled conditions as mentioned above.

Ovicides Applied on American Elm

The spray test applied December 4, 1938 (Table 5), shows four per cent "Spra-mulsion" to be the most effective ovicide with a 27.1 per cent egg control. Eight per cent and two per cent "Dendrol" followed with 20.5 per cent and 16.7 per cent kill being obtained, respectively. Neither of the lime sulphur solutions gave satisfactory results.

The second spray test applied March 3, 1939, (Table 6), shows that a higher egg kill was obtained by the use of late winter ovicides. Eight per cent "Dendrol" leads all ovicides with a 47.3 per cent

Table 5 - Field Tests of Early Winter Dormant Sprays Applied December 4, 1938 on the Eggs of <u>Stictocephala</u> <u>inermis</u> in American Elm Twigs at Stillwater, Oklahoma

Test Number	Date Counted	Materials Used	Per cent Dilution	Amount in Quarts	Condition of Eggs at Count: Total	Alive or Hatched	Parasitized	Dead: Number	Dead: Per cent	Per cent Control
28	5-6-39	Dendrol Miscible oil (93% actual oil)	8	1.1	577	372	9	196	33.97	20.5
30	do	do	4	3.5	510	357	3	150	29.41	13.8
37	do	do	2	2.4	438	296	8	134	30.57	16.7
12	do	Spra-mulsion Miscible oil. (actual oil 85%.)	8	1.3	548	432	0	116	21.17	3.0
16	do	do	6	1.8	618	431	3	184	29.77	14.2
24	do	do	4	2.5	522	309	3	210	40.22	27.1
26	do	do	2	2.2	476	343	1	132	27.73	11.2
40	5-8-39	Lime sulphur, 33° Baumé concentrate	Baumé 5	1.4	540	429	0	111	20.56	2.2
42	do	do	4	1.7	510	386	2	122	23.92	6.8
Check	5-6-39 to 5-18-39				3891	3159	14	718	18.45	

Table 6 - Field Tests of Late Winter Dormant Sprays Applied March 3, 1939 on the Eggs of *Stictocephala inermis* in American elm twigs at Stillwater, Oklahoma

Test Number	Date Counted	Materials Used	Per cent Dilution	Amount in Quarts	Total	Condition of Eggs at Count: Alive or Hatched	Parasitized	Dead: Number	Dead: Per cent	Per cent Control
45	5-8-39	Dendrol winter miscible oil. (93% actual oil)	8	1.5	515	221	0	294	57.09	47.3
47	5-10-39	do	6	1.25	516	348	0	168	32.56	17.0
50	do	do	4	1.25	535	405	1	129	24.11	6.8
52	5-8-39	do	2	1.75	530	374	2	154	29.06	13.1
55	do	Spra-mulsion miscible oil. (85% actual oil.)	8	1.25	560	365	0	195	34.82	19.7
58	do	do	6	1.50	564	293	3	268	47.52	36.0
60	do	do	4	2.25	510	350	3	157	30.78	15.5
65	5-11-39	do	2	2.25	524	434	2	88	16.79	-2.0
67	do	Lime sulphur 33° Baumé concentrate	Baumé 5	1.25	458	324	16	118	25.76	12.9
69	do	do	4	1.0	508	424	2	82	16.12	-2.7
Check 5-6-39 to 5-18-39					3891	3159	14	718	18.45	

control; six per cent "Spra-mulsion" and eight per cent "Spra-mulsion" follow next with 36.0 and 19.7 per cent egg control being obtained respectively. Lime sulphur sprays were ineffective as ovicides.

Table 7 gives the results of the third spray application applied March 22, 1939. Egg kill was higher in this application than the former two sprayings. Six per cent "Dendrol" led all materials in effectiveness by giving a 63.1 per cent egg control. Closely following the six per cent "Dendrol" was 0.1 per cent DNO spray dilution with a two per cent "Spra-mulsion" carrier, and six per cent "Spra-mulsion". These sprays gave controls of 61.9 per cent and 56.6 per cent in order listed.

In averaging the three spray applications, (Table 8), the six per cent "Dendrol" was omitted, since the first application did not include the six per cent spray. As a whole, the first application gave poor results, and consequently, by omitting the average of the six per cent "Dendrol", there would be less chance of misconstruing the summary. The summary shows eight per cent "Dendrol" to be the most effective as an ovicide giving a control of 37.1 per cent. Six per cent "Spra-mulsion" followed in effectiveness and four per cent "Spra mulsion" gave the next best control.

The test sprays applied March 22 show that adding a 0.1 per cent DNO to a two per cent "Spra-mulsion" spray gave almost as good control as six per cent "Dendrol" spray. This indicates that when this material is used, the amount of oil in the spray may be very materially reduced. The practicability of this combination depends upon the comparative price of the two materials used at the dilutions tested.

Table 7 - Field Tests of Delayed Dormant Sprays Applied March 22, 1939 on the Eggs of *Stictocephala inermis* in American elm twigs at Stillwater, Oklahoma

Test Number	Date Counted	Materials Used	Per cent Dilution	Amount in Quarts	Condition of Eggs at Count: Total	Alive or Hatched	Parasitized	Dead: Number	Dead: Per cent	Per cent Control
72	5-11-39	Dendrol winter miscible oil. (93% actual oil)	8	1.25	482	221	2	259	53.73	43.5
74	do	do	6	1.0	517	155	5	357	69.05	63.1
76	do	do	4	1.50	481	185	3	293	60.91	52.6
79	do	do	2	1.50	494	294	1	199	40.28	26.7
82	do	Spra-mulsion miscible oil. (85% actual oil.)	8	1.50	497	199	2	296	59.56	50.7
84	do	do	6	1.75	491	173	5	313	63.75	56.6
101	do	do	4	1.25	431	203	2	226	52.44	42.0
103	do	do	2	1.50	509	343	0	166	32.61	17.0
			Baumé							
113	5-17-39	Lime sulphur 33° Baumé concentrate	5	1.33	524	405	1	118	22.52	4.8
115	do	do	4	1.0	460	345	2	113	24.57	7.6
		Dinitro-o-cyclohexylphenol								
146	5-18-39	Dilution of 2% spra-mulsion plus DNO	0.1	1.25	486	150	7	329	67.70	61.9
117	do	do	0.05	1.50	476	183	2	291	61.13	52.7
148	do	do	0.025	1.25	476	317	0	159	33.40	18.0
Check 5-6-39 to 5-18-39					3891	3159	14	718	18.45	

Table 8 - Mean Average of Spray Tests of Winter Ovicides Against *S. inermis* Infesting American Elm Trees at Stillwater, Oklahoma

Materials Used	Per cent Oil in Spray	Per cent Control December 4	March 3	March 22	Mean
Dendrol	8	20.5	47.3	43.5	37.1
do	4	13.8	6.8	52.6	34.4
do	2	16.7	13.1	26.7	18.8
Spra-mulsion	8	33.0	19.7	50.7	24.5
do	6	14.2	36.0	56.6	35.6
do	4	27.1	15.5	42.0	28.2
do	2	11.2	-2.0	17.0	8.7

Ovicides Applied on Asiatic Elm

The spray test applied December 4, (Table 9), shows four per cent "Dendrol" to be the most efficient ovicide with a 80.3 per cent egg control. Eight per cent "Dendrol" and six per cent "Spra-mulsion" follow giving 67.5 and 61.6 per cent egg control respectively. Lime sulphur gave unsatisfactory results as an ovicide.

The second spray test applied March 3, (Table 10), shows a decrease in general ovicidal efficiency. Six per cent "Spra-mulsion" was the most efficient ovicide with a 74.3 per cent control. Eight per cent "Spra-mulsion" followed by two per cent shows next best control with 64.9 and 52.0 per cent egg control respectively. Lime sulphur was very unsatisfactory.

In the last spray test, (Table 11), eight per cent "Dendrol" leads with 73.1 per cent control, closely followed by six per cent and two per cent "Spra-mulsion" with egg controls of 70.2 and 69.1 per cent respectively. Lime sulphur and the DNO materials gave very unsatisfactory results as ovicides.

The average of the three tests is given in the Table 12. "Spra-mulsion" gave the most satisfactory results with 68.7 per cent egg control, the six per cent dilution giving the highest kill. Lime sulphur and the DNO dilutions were inefficient.

Spraying American elms in the delayed dormancy period, as indicated by Fig. 7 gave the best egg control. The Asiatic elm may be sprayed at any period from dormancy to delayed dormancy for good egg control as indicated by Fig. 8.

SUMMARY

Excessive scarring of American and Asiatic elms growing along

Table 9 - Field Tests of Early Winter Dormant Sprays Applied December 4, 1938 on the Eggs of <u>Stictocephala inermis</u> in Asiatic Elm Twigs at Stillwater, Oklahoma

Test Number	Date Counted	Materials Used	Per cent Dilution	Amount in Quarts	Condition of Eggs at Count: Total	Alive or Hatched	Parasitized	Dead: Number	Dead: Per cent	Per cent Control
10	5-3-39	Dendrol winter miscible oil. (93% actual oil.)	8	2.12	528	119	16	393	74.43	67.5
14	do	do	4	3.5	535	73	7	455	85.05	80.3
19	do	do	2	2.5	353	184	7	162	45.89	24.7
1	5-1-39	Spra-mulsion winter miscible oil. (85% actual oil.)	8	2.0	536	146	11	379	70.71	60.7
3	do	do	6	2.1	526	140	9	377	71.67	61.6
5	do	do	4	2.25	576	163	7	406	70.49	59.1
7	5-3-39	do	2	2.50	561	221	9	331	59.00	43.1
22	5-6-39	Lime sulphur 33° Baumé concentrate	Baumé 5	1.50	493	218	2	273	55.38	36.1
33	do	do	4	2.00	340	215	10	115	33.82	8.7
Check 5-3-39 to 5-18-39					3206	2217	51	938	29.26	

Table 10 - Field Tests of Late Winter Dormant Sprays Applied March 3, 1939 on the Eggs of *Stictocephala inermis* in Asiatic elm twigs at Stillwater, Oklahoma

Test Number	Date Counted	Materials Used	Percent Dilution	Amount in Quarts	Condition of eggs at count: Total	Alive or Hatched	Parasitized	Dead: Number	Dead: Per cent	Per cent Control
35	5-8-39	Dendrol winter miscible oil. (93% actual oil)	8	1.75	562	272	9	281	50.00	30.1
48	5-10-39	do	6	2.00	933	460	21	452	48.45	28.8
85	5-12-39	do	4	2.75	425	177	8	240	56.47	39.7
87	5-11-39	do	2	1.75	452	201	0	251	55.53	35.7
89	do	Spra-mulsion winter miscible oil. (85% actual oil)	8	1.75	436	106	3	327	75.00	64.9
90	do	do	6	2.00	410	73	2	335	81.71	74.3
91	do	do	4	1.75	463	153	9	301	65.01	50.7
95	do	do	2	2.25	407	135	4	268	65.84	52.0
97	do	Lime sulphur 33° Baumé concentrate	Baumé 5	1.25	420	285	3	132	31.43	1.9
99	do	do	4	1.00	433	276	0	157	36.26	7.8
Check 5-3-39 to 5-18-39					3206	2217	51	938	29.26	

Table 11 - Field Tests of Delayed Dormant Sprays Applied March 22, 1939 on the Eggs of Stictocephala inermis in Asiatic elm twigs at Stillwater, Oklahoma

Test Number	Date Counted	Materials Used	Per cent Dilution	Amount in Quarts	Condition of eggs at count: Total	Alive or Hatched	Parasitized	Dead: Number	Dead: Per cent	Per cent Control
105	5-11-39	Dendrol winter miscible oil. (93% actual oil).	8	1.50	511	95	6	410	80.23	73.1
107	5-16-39	do	6	1.50	376	116	0	260	69.15	55.3
109	do	do	4	2.00	382	178	1	203	53.14	32.7
111	do	do	2	3.00	453	172	1	280	61.81	45.4
128	5-18-39	Spra-mulsion winter miscible oil. (85% actual oil).	8	2.00	426	93	8	325	76.29	68.5
133	do	do	6	1.00	451	93	4	354	78.49	70.2
135	do	do	4	2.25	429	105	12	312	72.73	64.6
143	do	do	2	2.00	406	87	3	316	77.83	69.1
			Baumé							
154	do	Lime sulphur 33° Baumé concentrate	5	2.00	415	265	8	142	34.22	7.7
156	do	do	4	1.25	449	297	9	143	31.85	4.5
			% DNO							
158	do	Dilution of 2% spra-mulsion plus DNO	0.1	1.75	424	189	5	230	54.25	35.0
160	do	do	0.05	1.50	463	246	4	213	46.00	23.3
162	do	do	0.025	2.00	449	293	5	151	33.63	5.6
Check 5-3-39 to 5-18-39					3206	2217	51	938	29.26	

Table 12 - Mean Average of Three Spray Tests of Winter Ovicides Against S. *inermis* Infesting Asiatic Elm Trees at Stillwater, Oklahoma

Materials Used	Per cent Oil in Spray	Per cent Control			
		December 4	March 3	March 22	Mean
Dendrol	8	67.5	30.1	73.1	56.9
do	4	80.3	39.7	32.7	50.9
do	2	24.7	35.7	45.4	35.3
Spra-mulsion	8	60.7	64.9	68.5	64.7
do	6	61.6	74.3	70.2	68.7
do	4	59.1	50.7	64.6	58.1
do	2	43.1	52.0	69.1	54.7

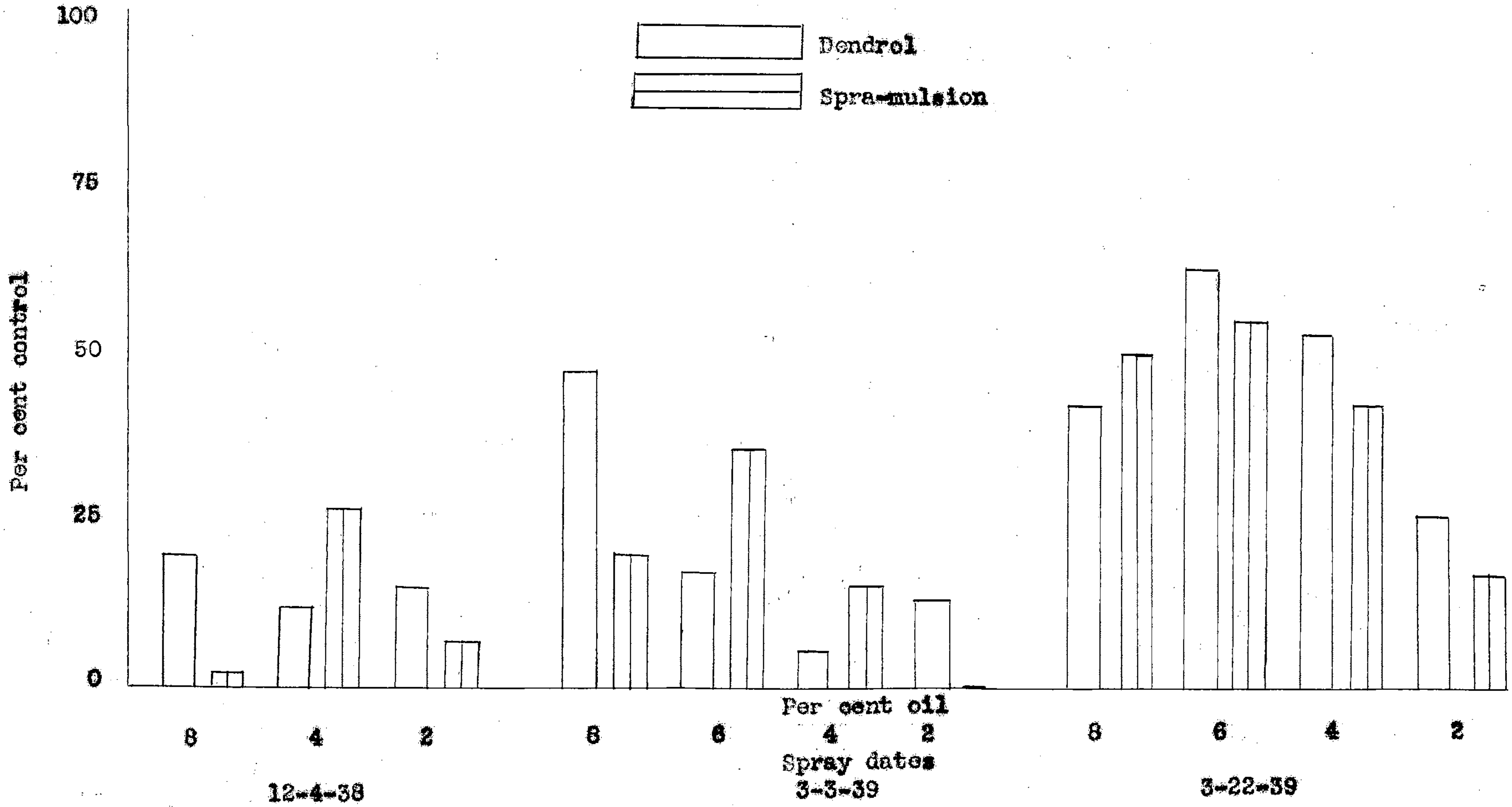


Fig. 7 - The action of "Dendrol" and "Spra-mulsion", winter ovicides, sprayed at different dates, against the eggs of S. inermis (Fab.) infesting American elm trees at Stillwater, Oklahoma.

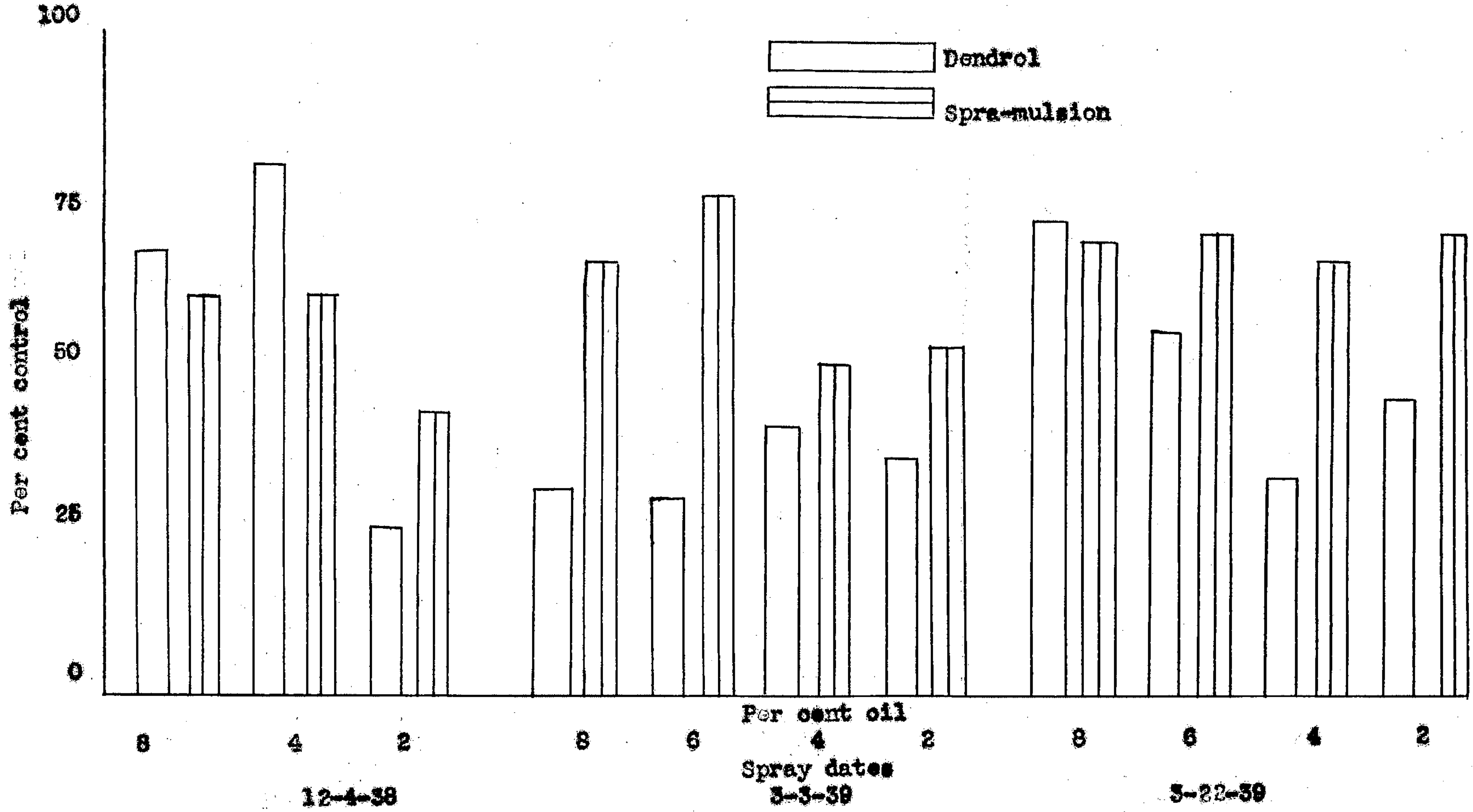


Fig. 8 - The action of "Dendrol" and "Spra-mulsion", winter ovicides sprayed at different dates, against the eggs of S. inermis (Fab.) infesting Asiatic elm trees at Stillwater, Oklahoma.

a highway near Stillwater, Oklahoma was found to be caused by the egg laying habits of Stictocephala inermis (Fab.), commonly known as the green clover tree hopper.

Eggs are deposited on the dorsal surface of two-three-and four-year old wood of American and Asiatic elm twigs in pouch-like cases holding from five to six eggs each.

The eggs hatch in April and May, and the nymphs fall to the ground where they feed on such plants as wild psoralea, false dandelion, and wild lettuce. They remain on these plants until they become adults in June and July. Neither the nymphs nor adults were ever found feeding on American or Asiatic elm. Females deposit their eggs from late July to the beginning of September. There is one generation a year.

Injury to the stem is brought about by the female when she inserts here saw-like ovipositor through the tender bark in the process of egg laying. Incisions often occur through the cambium layer and into the outer wood. These incisions may sever conductive tissues and may allow ingress by a pathogenic organism.

There was no significant difference in diameter growth the year following injury of non-infested over infested twigs in either the American or Asiatic species, but trees with excessive oviposition scars showed some dead tips of smaller branches which may have been due to this insect.

There was no apparent injury to the leaf development in the buds of either the American or Asiatic elms by the use of dormant oils to control an infestation of S. inermis.

Three spray applications on each species of elm were made during the winter and spring of 1938-39 to test ovicidal efficiency against the eggs of Stictocephala inermis. These sprays were applied December 4, 1938, March 3 and March 22, 1939.

The sprays tested were two commercial miscible oils known as "Dendrol" and "Spra-mulsion". Lime sulphur concentrate was also tested as was a material known as dinitro-o-cyclohexylphenol with a two per cent miscible oil as the carrier.

On the American elm in the late winter spray, applied December 4, the four per cent "Spra-mulsion" gave the best results. In the late winter spray, applied March 3, the eight per cent "Dendrol" gave the best control. A six per cent strength of "Dendrol" gave the best results in the delayed dormant spray applied March 22. Averaging all three applications, the highest control was obtained from eight per cent "Dendrol".

On the Asiatic elm, four per cent "Dendrol" gave the best results in the early winter dormant spray, six per cent "Spra-mulsion" the highest kill in the late winter spray, and eight per cent "Dendrol" gave the highest per cent control in the delayed dormant spray. Averaging the three sprays, six per cent "Spra-mulsion" gave the highest per cent control.

Highest kill was obtained from spraying in the delayed dormant spray for the American elm. For the Asiatic species, little difference was obtained in per cent control between any of the three dates of application.

Lime sulphur of either four or five degree Baumé was ineffective as an ovicide. The use of dinitro-o-cyclohexylphenol in a two per cent "Spra-mulsion" spray gave 61.9 per cent control on American elm when the trees were sprayed March 22. This combination, however, was ineffective as an ovicide on Asiatic elms.

Parasites were relatively unimportant in tree hopper control during the period of the experiment, but 29 per cent of the eggs were killed by other causes. There must also have been a very great mortality in the nymphs from the time of hatching until they located a suitable host plant.

Clean cultivation to destroy succulent weeds, especially wild psoralea may be used where the infestation is continually heavy each year and should be the best preventive.

RECOMMENDATIONS FOR CONTROL

The best time to spray American elms to control S. inermis proved to be late in March, but even then the maximum control obtained was only 63.1 per cent with a six per cent "Dendrol" spray. Better kills were obtained on Asiatic elm, but the data are quite conflicting concerning the best time to spray. On the average, eight per cent "Spra-mulsion" and eight per cent "Dendrol" gave the best results on this variety, but even here, satisfactory controls were not obtained, the maximum being 80.3 per cent secured with "Dendrol" and the highest kill being 74.3 per cent, obtained by "Spra-mulsion".

Owing to the fact that injury to the tree by S. inermis is more apparent than real, and since there is a high mortality of the insect during the egg and first nymphal stages, the value of spraying with dormant oils to kill the eggs is questionable. While the flight habits of the adult tree hoppers are not known and it may be possible that they migrate for considerable distances, a suggested preventive is weed control under the trees and nearby pastures, to prevent breeding, with

Psoralea tenuiflora var. floribunda as the most important weed host.

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