Oviposition of the wheat stem sawfly (Cephus cinctus, Nort.) with special reference to some morphological characteristics of vulgare wheats
by Joseph B Kreasky

A THESIS Submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of Master of Science in Entomology
Montana State University

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Experimental data concerning"the morphological relationships of the wheat stem sawfly (Cephas cinctus, Wort.) to its host plants as affecting oviposition are lacking in the literature. A study of some of these relationships on vulgare wheats was undertaken to increase our understanding of the oviposition habits of this insect. The activities of individuals were studied by observing the females as they oviposited and by making measurements and observations on the insects and the stems on which they oviposited. The following aspects of oviposition were investigated: (1) behavior of the female during oviposition; (2) effect of leg length and stem diameter on oviposition; (3) preference for particular internodes for oviposition; (4) incisions with respect to the alternating bands of stereome and chlorophyllous tissue of the stem; (5) incisions with respect to three regions of an internode; (6) effect of the leaf sheath on choice of a site for ovipos- ition; and (7) effect of the internal vascular bundles of the stem on the path of the ovipositor. The relationship, if any, between stem diameter and leg length was not found to be linear. Limits cannot be assigned to sawflies with particular leg lengths to prefer specific stem diameters for oviposition. Upper and lower limits of stem diameter outside of which oviposition is impossible, applied to a population of sawflies, would be so extreme that most small grains would have stem diameters included in such limits. The bands of stereome and the internal vascular bundles of the stem present obstacles to the path of the ovipositor. The upper internodes are preferred for oviposition, but no preference was observed for any particular region of an internode. The leaf sheath had no influence on the choice of an oviposition site.

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March, 1955

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Abstract

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INTRODUCTION

An understanding of the oviposition habits of an insect should be of paramount importance before setting out to solve a problem in economic entomology. Yet, while examining the literature, one becomes aware of the nearly complete lack of experimental data on the oviposition habits of the wheat stem sawfly, although observations are readily available.

At least as early as 1911, stem diameter was thought to exert some kind of influence on the preference of a host plant by this insect. Criddle (1911) reported that the chief food plants of the sawfly included all grasses of the genus Agropyron except A. tenerum which proved immune. This immunity was due, Criddle reported, to the more slender stems of this species. Since he gave no indication of just what the exact mechanism was that provided this immunity, the reader might question whether slender stems provided a physical difficulty between adult and host as affecting oviposition or whether resistance was effected by some other factors.

Ainslie (1920), observed that a female sawfly, after settling on a suitable host plant, paused many times on her way up and down the stem and attempted to make an incision at each pause. This would indicate that certain parts of the stem are preferred for oviposition. The same author, Criddle (1923) and Manson (1932) described how the female clasps her hind legs around the stem and, arching her abdomen, inserts the saws of the ovipositor, the direction of which might be changed slightly several times before complete penetration is achieved. Criddle (1923) stated: "On one occasion an individual was seen to thrust her ovipositor into a stem 14 times, 7 times almost exactly in the same spot. Eventually, after 9 minutes, she placed an egg just above the top joint." These facts point to the possibility that there might be morphological obstructions within the tissue of the host plant.

Farstad (1940) felt that oviposition occurred only within a definite stem diameter range. He cited an instance, in 1937, of the failure of oats at Nobleford, Alberta, to receive a severe infestation of eggs. It was found that the majority of eggs were laid in stems with diameters ranging from 2.16 mm. to 2.95 mm., while the mean diameter of all stems was 3.17 mm. It was concluded from this study that stem diameter was important in that it prevented the ovipositing female from being able to encircle the stem with her metathoracic legs.

Roemhild (1954) indicated that the upper two-thirds of an internode was the preferred place for oviposition in eight small grains studied.

The present investigation, then, was undertaken for the purpose of expanding the findings of Farstad (1940) with relation to stem diameter and leg length by studying individuals and their choice of oviposition sites and to provide information on other morphological factors which might be pertinent to this insect-host relationship.

Preliminary investigations of techniques for use in this study included (1) attempts to determine the resistance of the stem to puncturing by mechanical means; (2) a simple, direct method of determining the extent of lignification within the host stem; (3) direct observations and measurements of caged, ovipositing females; and (4) comparison of the gross morphology of the stem in relation to the oviposition incision. The first two of these were abandoned early in the investigations. The inability to devise a mechanical apparatus comparable to the "sawing" employed in the act of oviposition led to the rejection of number one. The method of determining the extent of lignification within the host stem involved the use of mounted stem sections which were stained to show lignin deposition. This technique was discarded because of the unreliability of sections to absorb stains uniformly, even when treated as nearly alike as possible. It is suggested that quantitative techniques would be the most meaningful in determining extent of lignification.

Numbers 3 and 4 are reported in the remainder of the present study.

My thanks are extended to the Entomology Research Branch of the Agricultural Research Service and to Montana State College for their cooperation in making this work possible. Specifically, I wish to thank Mr. W. Baker, Mr. E. Davis, Mr. P. Luginbill, Jr., Mr. W.

Boundy, and Mr. H. Somsen, all of the Entomology Research Branch, and Mr. R. Froeschner, Mr. J. Pepper, Mr. E. Hastings, Mr. B. Ostle, and Mr. G. Roemhild, all of Montana State College.

TECHNIQUE

Tests were conducted at experimental plots which were located just east of Choteau, Montana, during the summers of 1953 and 1954, and in the greenhouse at Montana State College, Bozeman, during the winter of the same years. The following aspects of oviposition were investigated: (1) behavior of the female during oviposition; (2) effect of leg length and stem diameter on oviposition; (3) preference for particular internodes for oviposition; (4) incisions with respect to the alternating bands of stereome and chlorophyllous tissue of the stem; (5) incisions with respect to three regions of an internode; (6) effect of the leaf sheath on choice of a site for oviposition; and (7) effect of the internal vascular bundles of the stem on the path of the ovipositor.

Many sawflies, both males and females, were caged over wheat plants and samples of ovipositing females and the stems on which they oviposited were taken. Wheats used in the tests were all vulgare type wheats—Rescue, Thatcher, and Yogo winter wheat. Sawflies were obtained either by netting from the field or by rearing them at room temperature in the laboratory from infested stubble. The latter were previously subjected to refrigeration to break diapause.

After caging insects on wheat, females were carefully watched for signs of interest in oviposition. When an individual was found inserting her ovipositor, the region of the stem was marked with a small amount of a saturated solution of eosin in 95 percent ethyl alcohol applied with a small camel's hair brush. This was done as close to the female as possible without disturbing her. After withdrawal of the ovipositor, she was caught and placed in a vial of 50 percent ethyl alcohol. The corresponding stem was also taken and, by means of a binocular microscope, the incision was found and data recorded as to the relationship of the incision with respect to the stereome, chlorophyllous tissue, and leaf sheath. The region of the internode in which the egg was laid and the particular internode were also recorded at this time. These data having been noted, the part of the stem on which the incision was made was cut from the plant with a razor blade and placed in a vial which contained the preservative-fixative, formalin-aceto-alcohol, more commonly known as FAA. Each stem section and the corresponding sawfly were given the same number so that a comparison could be made at a later date. Stems and sawflies were brought into the laboratory where the left hind leg of each sawfly was measured with an ocular micrometer.

The stems were dehydrated with the ethyl alcohol and tertiary butyl alcohol dilution method as recommended by Johansen (1940) previous to sectioning with paraffin as the embedding medium. Permanent mounts of the stems through which the ovipositor passed were made and stained with alcoholic safranin and fast green. All sections were cut at a thickness of 15 microns. After completion of the sectioning, the internal anatomy of the stem and the incision made by the ovipositor were observed and the diameter of the stem was recorded.

Because wheat stems are rarely circular in cross section and more often ellipsoidal, two measurements were made on each stem, the longest and the shortest distances across the stem. These two figures were then averaged, so that a comparison of all stems would be possible.

In noting the particular internodes on which females oviposited, the following method was adopted. At the top of the plant, the uppermost leaf was stripped off down to its base or node. The number of clearly visible nodes was then counted starting from the bottom with node number one and proceeding up to the top of the plant. The incision was recorded as having occurred between two numbered nodes; or, if the incision were made above the uppermost visible node, it was recorded as being between the number of that node and the next consecutive number. For instance, if an incision occurred above the second node on a plant which had two visible nodes, the designation 2-3 was given that incision.

It was hoped that the above method would be more meaningful than numbering internodes on which incisions occurred. Numbering internodes is a fair appraisal of the stage of growth of a wheat plant only when it is mature. With immature plants, from which most of the samples were taken, the problem of how to number the very small, young internodes at the top of the plant was a factor which, it was thought, would lead to extensive ambiguity concerning the development of the plant.

EXPERIMENTAL RESULTS AND DISCUSSION

Behavior of the Female During Oviposition

Usually alighting near the top of the plant, the gravid female proceeds immediately down the stem toward the base of the plant. Her temperament is one of preoccupation as she moves rapidly in somewhat jerky movements, and at the same time touches her antennae to the stem at regular intervals. Upon reaching the lowest internode, she usually reverses her direction and proceeds up the stem in the same manner as before. After reaching the top of the plant, she either flies off to another plant or again heads downward and attempts oviposition at a suitable spot. This ritual of traversing the stem before ovipositing would suggest that a careful survey of the entire stem is made before oviposition is attempted.

When the female finds a seemingly desirable spot on the stem, she firmly grips it by encircling it with her metathoracic legs. Then, with her abdomen arched, she touches the stem with the tips of the ovipositor sheaths. The position of the sheaths may be moved slightly or they might be dragged along the stem for a short distance if the first chosen spot is undesirable for some reason. Examination of the ovipositor sheaths revealed many sensory setae (see Figure 6) which might be the receptors of unknown stimuli that are instrumental in the search for a suitable part of the stem. Just before insertion of the blades of the ovipositor, the sheaths are raised to make an angle considerably more than 45 degrees with the ovipositor which is then probed into the stem rather slowly. Partial insertions and with-drawals usually occur several times before complete penetration is achieved.

After the ovipositor has been completely inserted, the insect's body assumes a position with the abdomen slightly arched, or in some cases, almost parallel to the stem. She then remains motionless for a short time. The writer believes this to be the point at which the egg actually passes into the stem of the host plant. After a varying period up to several minutes in this position, the abdomen is again strongly arched and the ovipositor is withdrawn.

It was observed that the time required to oviposit in hollow-stemmed wheats was considerably shorter than that in solid-stemmed wheats. The need of the female to hollow out a cavity for reception of the egg in solid-stemmed hosts is probably the reason. Compare Figures 4 and 5.

It has been noted that the antennae of the sawfly are used while searching for a place in which to oviposit. This habit of "drumming" the antennae while walking up and down the stem was, at first, thought to play some part in the process of egg laying. However, both male and female drumming occurs whenever the insect is walking, whether on a stem or some other surface. Severance of the antennae of a number of individuals revealed no difficulty in their ability to insert their ovipositors, although they more often assumed a position with head upward, instead of the more typical posture of head downward.

Effect of Leg Length and Stem Diameter on Oviposition

Tables I and II show frequencies of stem diameters accepted for oviposition and of leg length encountered, respectively. Graphical representations of these two tables are shown in Figures 1 and 2. These data indicate that the population from which the samples were drawn is approximately normally distributed with respect to leg length and stem diameters chosen for oviposition.

From Figure 1 it can be seen that, out of a relatively small group of sawflies from a very large population, oviposition is quite possible over a large range of stem diameters. Unfortunately, it cannot be concluded that any of these stem diameters are more acceptable than others, in spite of the appearance to the contrary. It would be necessary to compare the frequency of stem diameters of a random sample of all wheat used in the experiments with Table I and Figure 1. This frequency is not known. It is within the realm of possibility that those stem diameters which were most frequently accepted for oviposition occurred most often in the population and that their acceptance might not have been an exercise of choice on the part of the sawfly.

Table I. Frequencies of Stem Diameters Accepted for Oviposition by 195 Individuals.

Stem Diameter in mm.	1.81-1.90	1.91-2.00	2.01-2.10	2.11-2.20	2.21-2.30	2.31-2.40	2.41-2.50	2.51-2.60	2.61-2.70	2.71-2.80	2.81-2.90	2.91-3.00
Frequency	4	2	4	2	7	6	12	9	14	19	26	19
Stem Diameter	3.01-3.10	3.11-3.20	3.21-3.30	3.31-3.40	3.41-3.50	3.51-3.60	3.61-3.70	3.71-3.80	3.81-3.90	3.91-4.00	4.01-4.10	4.11-4.20
Frequency	17	16	10	10	8	3	2	2	1	1	0	1

Table II. Frequencies of Leg Lengths Occuring in 195 Individuals.

Leg Length in mm.	4.31-4.50	4.51-4.70	4.71-4.90	4.91-5.10	5.11-5.30	5.31-5.50	5.51-5.70	5.71-5.90
Frequency	1	1	2	5	8	12	21	20
Leg Length	5.91-6.10	6.11-6.30	6.31-6.50	6.51-6.70	6.71-6.90	6.91-7.10	7.11-7.31	7.31 +
Frequency	28	24	23	15	13	6	10	2

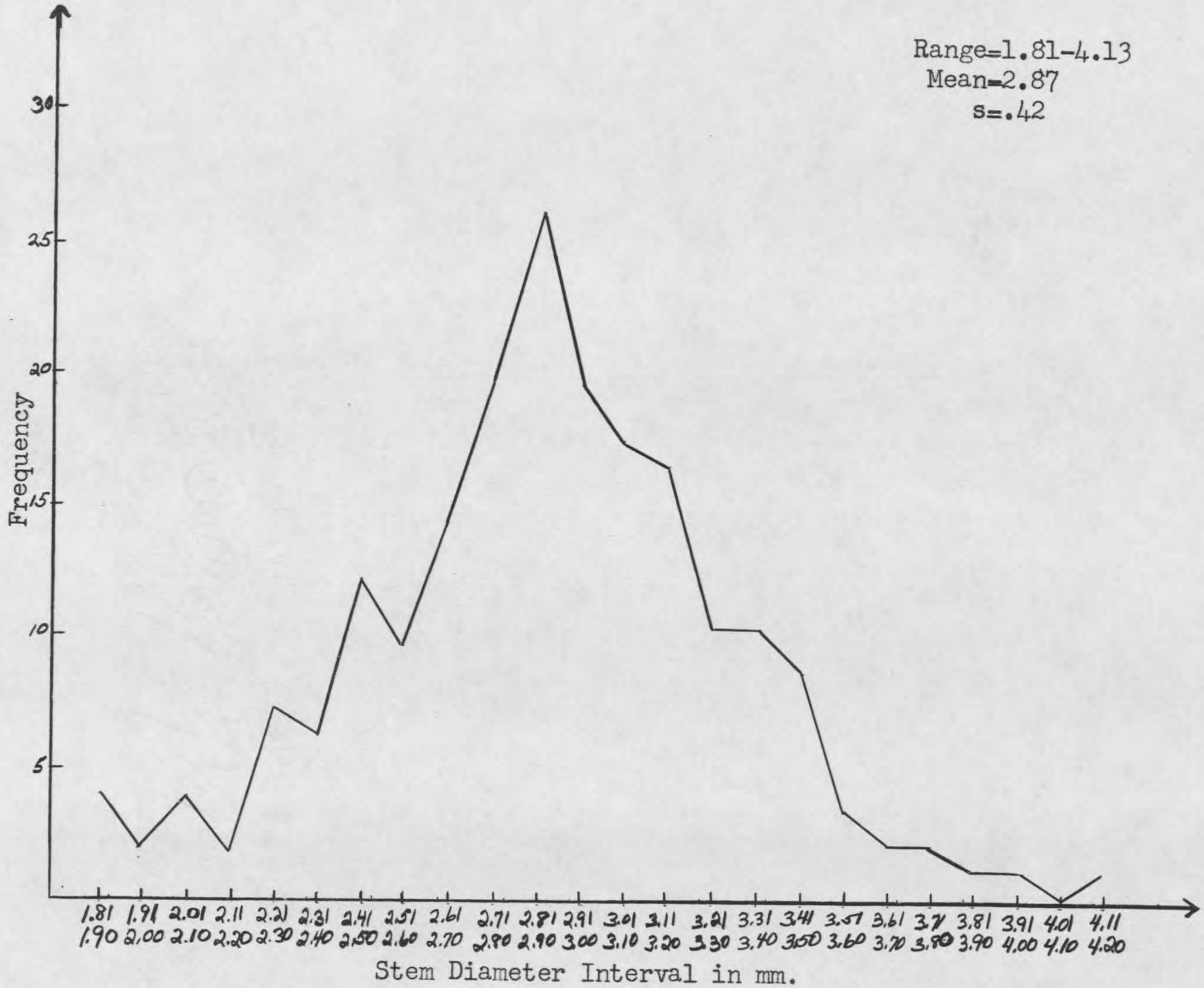

Figure 1. Frequency of Stem Diameters Accepted for Oviposition.

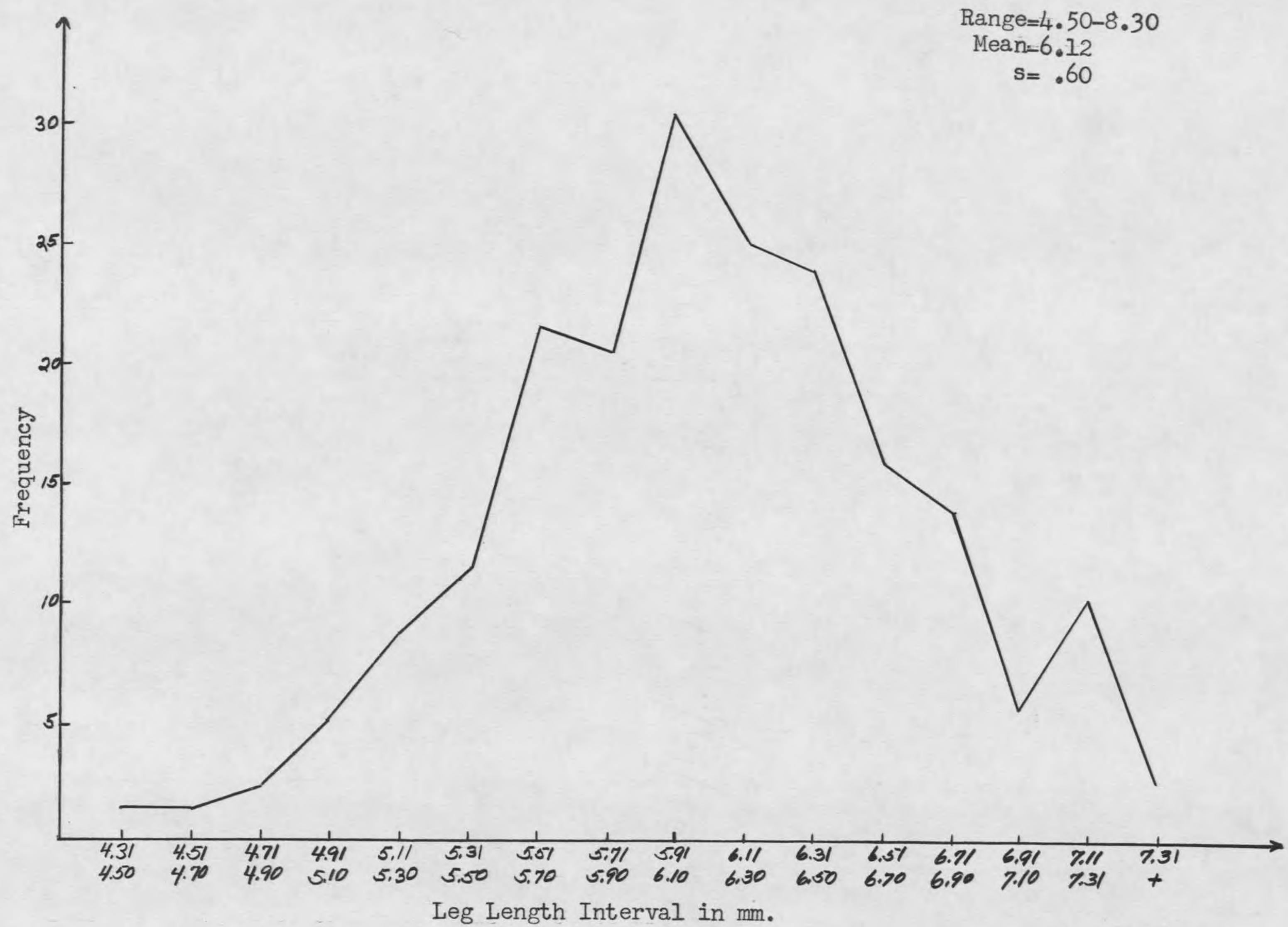

Figure 2. Frequency of Leg Lengths Encountered.

Table III. Frequency, Average Stem Diameter, and Range of Stem Diameters Accepted for Oviposition by Sawflies of Various Leg Lengths.

Leg Length Interval	Frequency	Stem Diameter	
		Range	Average
4.50-4.70 mm.	1	2.29 mm.	2.29 mm.
4.71-4.90	4	2.75-3.09	2.94
4.91-5.10	5	2.48-3.42	2.82
5.11-5.30	8	2.65-3.41	2.98
5.31-5.50	12	1.89-3.58	2.76
5.51-5.70	21	2.31-3.97	2.93
5.71-5.90	20	2.25-3.75	3.08
5.91-6.10	28	2.18-3.48	2.89
6.11-6.30	24	1.95-4.13	2.81
6.31-6.50	23	2.28-3.88	2.95
6.51-6.70	15	2.15-3.50	2.89
6.71-6.90	13	2.00-3.58	2.87
6.91-7.10	6	1.90-3.33	2.64
7.11-7.31	10	1.85-3.18	2.53
7.31 ≠	2	2.95-3.20	3.08

Table III shows the number of sawflies, grouped by leg length intervals of .20 mm., and the various ranges and averages of stem diameters on which individuals within these intervals oviposited. In Figure 3, the graphical counterpart of Table III, the relationships of the ranges and means of the groups are shown by lines which connect these statistics. It is immediately apparent that the extremes of stem diameter chosen for oviposition were not chosen by individuals with extremes in leg length as would be expected if the large and small diameter stems could be utilized only by sawflies of correspondingly long and short leg lengths. As a matter of fact, the largest diameter of stem accepted for oviposition was suitable

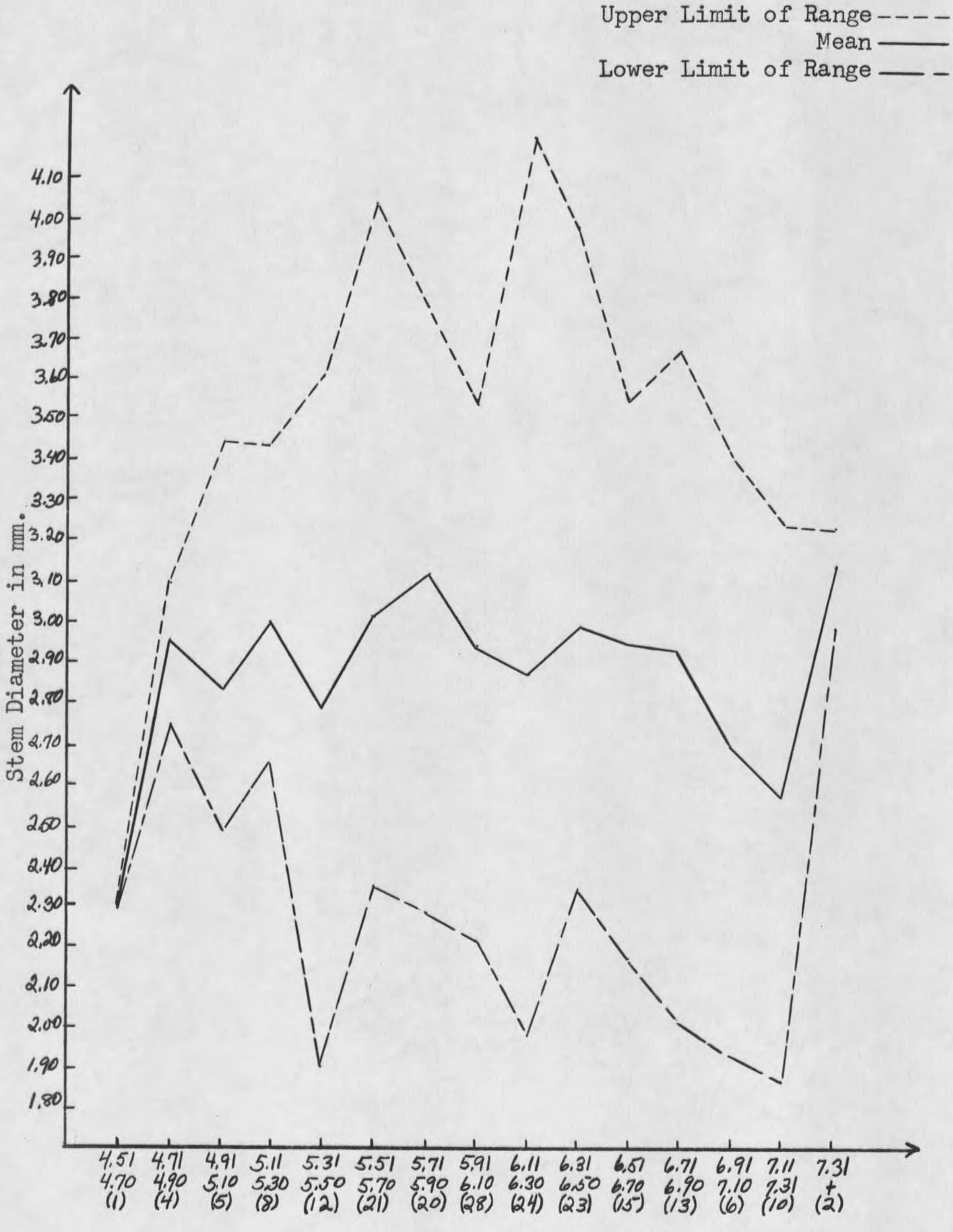

Figure 3. Frequency, Range, and Mean of Stem Diameters Accepted for Oviposition by Sawflies of Various Leg Lengths.

for an individual that had a leg length which fell into the leg length interval of 6.11 mm. to 6.30 mm., which is hardly an extreme. Conversely, the smallest diameter of stem accepted was suitable to an individual that had a leg length between 7.11 mm. and 7.31 mm., a relatively long length of leg. If stem diameter and leg length are related directly, it would be expected that the largest stems would be chosen by sawflies with the longest legs so that the line which connects the upper limits of stem diameters accepted for oviposition should show a more or less steady upward trend. A glance at the graph does not bear this out. A steady increase does occur at first but it is not consistent, particularly not after reaching the interval of 6.11 mm. to 6.30 mm. where a sharp decline begins. Similarly, it would be expected, if the hypothesis concerning stem diameter and leg length is correct, that the lines which connect the means and lower limits of stem diameters of the groups should also show an upward trend, but it is obvious that they do not.

These facts show, along with the insignificant correlation coefficient of -.099, that the relationship, if any, between leg length and stem diameter is not linear.

The possibility of the existence of lower and upper limits of stem diameter beyond which sawflies would not be able to insert their ovipositor has not been ruled out; however, these limits would be so extreme that most small grains would have stem diameters occurring within those limits. Farstad (1940) reported stem diameters for seven grains to be: wheat (Reward) 2.23 mm.; oats (Legacy) 2.86 mm.; wheat (Major) 2.93 mm.; wheat (Golden Ball) 3.32 mm.; oats (Gopher) 3.47 mm.; barley 3.89 mm.; oats (Banner) 4.32 mm. All of these except Banner oats have stem diameters which were readily accepted for oviposition in this study. Stem diameter, then, cannot be considered to be a critical factor with regard to the ability of females to insert their ovipositors in most normally-seeded small grains.

It is improbable that even approximate limits could be set with regard to leg length and stem diameter as affecting oviposition from these data. It might be desirable, however, to obtain more sawflies at both extremes of leg length and release them on stems of various diameters, since the number used at these extremes was small. Such an investigation would involve measuring hundreds of live insects, which might render this method impractical. Growing wheat stems with an adjustment in environmental conditions so as to produce uniformly small diameter stems would not seem to be of much value, since the long-legged individuals are quite capable of ovipositing on narrow stems; therefore, the results would probably be similar to those expressed by the graph in Figure 3.

Severing the hind tarsi of the legs in order to produce short-legged individuals was tried but was considered valueless because these individuals experienced loss of balance and difficulty in walking on flat surfaces, so it is inconceivable that they would have been able to climb a cylindrical stem.

An attempt was made to try to get sawflies to insert their ovipositors into stems without benefit of being able to encircle the stem completely with the hind legs. This was done by splitting the stems of several plants between the nodes, but leaving the nodes intact. Strips of white paper were then inserted between the two halves of the internodes, extending far enough on each side of the stem so that the sawfly could not grasp any more than half the stem. No individuals were observed to oviposit in this manner, but one was able to insert her ovipositor when she assumed a position at the end of the paper; i.e., near the node where she was able to grasp the stem with one hind leg while the other remained on the paper. Many individuals were observed to make incisions immediately above or below the nodes where no paper was inserted. It seems that the hind legs are important to the process of oviposition and that females cannot make incisions without grasping an object.

Preference for Internodes

Farstad (1940) stated that the upper, actively elongating internodes were preferred to the lower ones. This does not mean that elongation in itself is necessary, but merely indicates that some unknown factor or factors associated with elongation are preferred. Percival (1921) in The Wheat Plant said: "In the lowest internodes, the walls of the parenchyma become thickened and lignified; the tissue then materially assists the hypodermal stereome in strengthening the base of the straw." It might be expected, then, that the lower internodes would be avoided because of the difficulty in penetration of the lignified tissue.

Table IV. Choice of Internodes for Oviposition.

Number Visible Nodes	Number and Percent of Incisions Between Nodes												Total Incisions
	*G-1		1-2		2-3		3-4		4-5		5-6		
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	
1	5	83	1	17	–	–	–	–	–	–	–	–	6
2	3	8	36	92	0	0	–	–	–	–	–	–	39
3	0	0	20	27	34	46	20	27	–	–	–	–	74
4	1	2	1	2	8	14	23	41	23	41	–	–	56
5	0	0	0	0	0	0	0	0	0	0	5	100	5

*Ground

Table IV shows the preference for internodes by gravid females. It can be seen that there is a decided preference for the younger, elongating internodes of the stem which becomes pronounced after two visible nodes have been formed. When the plants were well headed out and close to maturity, all incisions occurred at the very top, although it is conceded that there were only five observations on plants at this stage of development. These are, however, consistent with the trend shown in plants with fewer visible nodes.

Since insects were not caged on wheats in all stages of development, Table IV should not be construed to mean that plants in any particular stage of development are preferred over others.

Incisions with Respect to the Alternating Bands of Stereome and Chlorophyllous Tissue

Observations were made on the number of incisions that either pierced the alternating bands of stereome tissue, which surrounds the vascular bundles of the leaf sheath and stem, or the bands of chlorophyllous tissue. The number of incisions which occurred on the chlorophyllous bands was overwhelmingly greater than that on the stereome. Out of a total of 212 observations, only 7 (3 percent) were made through the stereome, while 205 (97 percent) were made through the chlorophyllous tissue. It is possible that the number on the stereome was even lower because of the difficulty in being able to discern the exact position of the incision which was in close proximity to the stereome band. Such uncertain observations were counted as piercing the stereome.

The most probable reason for the preference for the chlorophyllous bands as placed for oviposition would seem to be that it is more yielding than the tough, fibrous stereome. If a pin is thrust into a stem several times, it will be seen that when it strikes the stereome near the edge, the tissue moves away as pressure increases. It is possible that the ovipositor of the sawfly deflects the stereome in a somewhat similar way or vice versa.

Incisions with Respect to Three Regions of an Internode

The position of the incision was recorded as being approximately in the top, middle, or bottom third of that internode. The results are presented in Table V. A preference for any of these regions is not clearly indicated by the data.

Table V. Number and Percent of Incisions on Three Regions of an Internode.

Region	Number	Percent
Top	78	37
Middle	70	33
Bottom	64	33

Roemhild (1954) found that the upper two-thirds of an internode was preferred as an oviposition site in his study of resistance. A probable reason for this is that Roemhild recorded the incidence of incisions in terms of eggs found at weekly intervals. According to Percival (1921), the region of elongation of an internode lies at its base, so it is possible that, if several days had passed before a count was taken, many of the eggs which were laid at the bottom would be found in the middle region of the internode. Likewise, those eggs laid in the middle region might be found in the upper one-third of the internode after a period of time.

Effect of the Leaf Sheath in Choosing a Site for Oviposition

From a total of 124 observations, 97 (78 percent) incisions occurred on the leaf sheath while 27 (22 percent) occurred on the naked stem. The higher percentage of punctures through the sheath is probably not an exercise of choice but results from the fact that more of the stem is covered by the leaf sheath than is naked. The leaf sheath does not interfere with the process of oviposition.

Effect of the Internal Vascular Bundles of the Stem on the Path of the Ovipositor

It was noticed at the beginning of these experiments that there seemed to be a tendency to avoid the stereome and a preference for the chlorophyllus tissue for insertion of the ovipositor. This has been borne out by the accumulation of subsequent data. To find if the vascular bundles of the interior of the stem had a similar effect, the stems were sectioned, stained, and mounted. If the insertion of the ovipositor was complete and the stem sectioned reasonably well, little difficulty was experienced in being able to recognize the incision in serial arrangement of the sections. With small or incomplete incisions, however, it was impossible to tell with certainty whether cuts were made by the ovipositor, faulty microtoming, or some other cause. Similarly, extensive tearing of the sections could render large incisions unfit for this study. For these reasons many of the stem sections having incisions were not included in the data. Typical incisions in hollow-stemmed and solid-stemmed wheats are shown in Figures 4 and 5.

The data for pierced and unpierced vascular bundles revealed that in 17 instances (21 percent) the vascular bundles were pierced. There were 64 instances (79 percent) in which the bundles were not pierced. Consideration was given only to the large vascular bundles located in the interior of the stem; those of leaf sheath and the small bundles near the periphery of the stem were disregarded. A bundle was considered pierced if the ovipositor completely ruptured it or merely passed between the tubes of the xylem. A bundle was not considered pierced if the ovipositor grazed the xylem but did not pass between the tubes.

Some sort of comparison of the theoretical and experimental probabilities of pierced and unpierced vascular bundles would have to be made if anything concerning their influence on the path of the ovipositor is to be concluded. It would, therefore, be desirable to know what the chances are that an ovipositor would strike one of these bundles if it were inserted at random. A comparison of this theoretical probability with that of the experimental probability would shed some light on this question.

Twenty of the best stem sections were taken and the diameters of the rings of the large, interior vascular bundles were measured and the circumferences of the rings calculated. The total widths of the individual bundles were measured and the percent of the circumference of the ring which was occupied by the bundles noted. After this was done for each of the twenty stems the percentages were averaged. The figure arrived at, 38 percent, would be the probability that an ovipositor would strike a bundle if it were inserted at random. It follows that there would be a 62 percent chance of missing a bundle under the same conditions.

A chi-square test revealed a value for chi-square of 12.3, while there is a 99.5 percent chance that chi-square will be less than 7.88, provided that the theoretical and experimental probabilities are not significantly different. This would indicate that, since actual count showed 79 percent misses, something other than chance is involved in causing the incision to be placed between the vascular bundles.

In calculating the theoretical probabilities two assumptions were made. First, the stem is circular, and second, the ovipositor is inserted in a straight path. Neither of these is always true, the stem being more often ellipsoidal rather than circular and the path of the ovipositor frequently oblique.

The vessels of the xylem, in all likelihood, offer resistance to the ovipositor. These vessels are distinctly and heavily lignified. Many cases were noted in which the ovipositor apparently grazed one of them and was deflected. In only two cases were the pierced bundles seen to be completely ruptured; the others seemingly had the xylem vessels pushed apart by the ovipositor.

CONCLUSIONS

1. The relationship, if any, between leg length and stem diameter as affecting the ability of the wheat stem sawfly to oviposit is not linear. Limits cannot be assigned to sawflies with particular leg lengths to prefer specific stem diameters for oviposition.

2. Upper and lower limits of stem diameter, outside of which oviposition by a population of sawflies would be impossible, are likely to be so extreme, if they exist, that most small grains will have stem diameters within that range.

3. Ovipositing females more often make incisions through the bands of chlorophyllous tissue rather than through the bands of stereome.

4. There is no preference for any particular region of an internode for oviposition.

5. The upper internodes are preferred for oviposition in plants with two or more visible nodes.

6. The leaf sheath has no effect on the site accepted for oviposition.

7. The large vascular bundles of the interior of the wheat stem present obstacles in the path of the ovipositor.