METHODS OF DECREASING WINTER MORTALITY OF THE SOUTHWESTERN CORN BORER TO OBTAIN MOTHS FOR EXPERIMENTAL STUDIES

by

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INTRODUCTION

The adult southwestern corn borer, Diatraea grandiosella Dyar, is a moth of the family Pyralidae, subfamily Crambinae. Its close relatives of economic importance include the southern cornstalk borer, Diatraea crambidoides Grote, and the sugar cane borer, Diatraea saccharalis (Fab.). The European corn borer, Pyreusta nubilalis (Hubn.) belongs to the same family but to a different subfamily.

The southwestern corn borer undergoes complete metamorphosis in its development. It overwinters as a full grown borer in the base of the corn stalk. The majority of the overwintering borers differ from the first generation and the earlier instars of the second generation borers by being a dull white color devoid of spots. Occasionally a spotted borer will prepare to overwinter. Preparation for overwintering begins by mid-September and is nearly complete by the last week in October.

In preparation for the overwintering period, the borer tunnels down to the base of the stalk. Before hibernation begins most of the borers ascend the tunnel to about four inches above the ground level and ream the interior of the stalk until only a very thin periferal layer of the stalk remains. Wilbur, Bryson and Painter (1943) have applied the term "girdling" to this internal reaming. This girdling may cut completely through the outer shell and allow the stalk to lodge immediately, or may cut only a portion of the circumference, allowing the stalk to

remain standing for some time. The girdling is well concealed and is usually not detected unless closely examined. However, only a slight pressure upon the stalk will cause it to fall. After the process of girdling is completed, the borer descends the tunnel. The cell is then prepared for overwintering. It is cleaned out and lined with silk. A cap or plug of silk and frass is then placed at the top and the borer goes to the base of the stalk. It was found that most borers placed in glass tubes and overwintered in the laboratory would molt once and sometimes twice subsequent to preparation of the hibernation cell. Whether this is done in nature is not known.

Since 1940, the southwestern corn borer has caused increasing damage in the corn growing regions of southcentral and southwestern Kansas. The damaging effect of the southwestern corn borer to the corn crop in nine counties in southcentral Kansas has resulted in a decrease of 97.8 percent of the acreage.[1]

It has long been known that only a small percentage of the borers, sometimes less than one percent, are able to survive the overwintering conditions in nature in Kansas. In spite of the high winter mortality, during favorable seasons the few survivors have been sufficient to reinfest corn to an extremely damaging degree. The percentage of overwintering borers which pupate and emerge as adults is so small that eperimental work on the first generation has been limited.

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1. Wilbur, D. A., H. R. Bryson, and R. H. Painter, "Southwestern corn borer in Kansas". Kansas Agr. Expt. Sta. Bul. 317. Revised. In print.

The purpose of the research, from which data this thesis was written, was to develop methods for the successful overwintering of sufficient quantities of borers which would pupate and emerge as adults to infest corn for experimental study of the first generation borers. This work was made possible by the financial support of Agricultural Experiment Station Project Match 283, Kansas State College, Manhattan, Kansas.

REVIEW OF LITERATURE

The species Diatraea grandiosella Dyar was originally described in 1911 by H. G. Dyar (Dyar, 1911) from a specimen which was taken at Guadalajara, Mexico. According to Davis et al. (1933), C. H. Gable and R. A. Epperson, in an unpublished manuscript on the species, recorded its presence in New Mexico in 1913. How long it was present in the United States before this is unknown.

A survey of the literature revealed that little work had been done on the factors affecting the overwintering borers of Diatraea grandiosella Dyar. Davis et al. (1933) described methods of rearing summer generations from eggs which had been deposited on corn leaves, waxed paper, salve tins and small glass vials. They indicated that there was no variation between specimens reared in field and indoor cages as to emergence, mating and oviposition.

In the same publication, these authors described the effects of different treatments of stubble on emergence as a possibility

for artificial control. One hundred stalk bases were buried horizontally in each of three wooden frames at depths of two, four and six inches, respectively. The frames were covered with wire screens to catch the moths. No moths emerged from stalk bases buried at depths of four and six inches, and only two emerged from those buried two inches deep.

In another experiment described by the same authors, four groups of eight infested stalks were treated as follows: Two lots were buried at depths of eight and four inches, respectively, the third lot was set in a normal growing condition and the fourth was freed from soil and laid on top of the soil. No moths emerged from stalk bases buried eight and four inches or from those on the surface. Six moths emerged from those in the normal growing condition and one was found alive but unemerged in a pupal skin.

O'Kane and Lowry (1927), in a publication on the life history of the European corn borer in New Hampshire, obtained material for their studies through modified conditions of overwintering. Due to the difference in overwintering habits of the southwestern corn borer and the European corn borer, these methods could not be applied to the overwintering of Diatraea grandiosella Dyar. However, at the beginning of spring, the stalks, which they had carried through the winter, were dissected and the borers removed and placed in three inch sections of quarter-inch glass tubing. These were placed where they were not exposed to sunlight. The rate of pupation under these conditions was delayed somewhat from that in nature. In the same experiment the borers obtained from the overwintered stalks were reared in homeopathic

vials three inches long and three-fourths of an inch in diameter. The open end of the vial was placed in a shallow hole in a plaster of Paris block. The top of the plaster of Paris block was provided with a depression into which water was poured every two to four days. This kept the entire block moist thus providing suitable moisture in the vials. Each block held 58 vials.

Other literature investigated on the overwintering of the European corn borer, the southwestern corn borer and the southern cornstalk borer (Diatraea crambidoides Grote) pertained to physiological or anatomical aspects of the problem, and were not applicable to the scope of this investigation.

METHODS AND MATERIAL

The specimens for this work were obtained from Hutchinson, Kansas, through the cooperation of Mr. Herbert H. Walkden of the Bureau of Entomology and Plant Quarantine.

Some 1800 corn stalk bases, each girdled, indicating the presence of an overwintering borer, were gathered in the fall of 1948 from the experimental plots at Hutchinson and the farm of Mr. Melvin Siefke at Hutchinson. Care was taken in the collection of the stalk bases to avoid unnecessary handling. One thousand and forty stalk bases were placed in different ecological situations in the Bureau of Entomology and Plant Quarantine Experimental Field at Hutchinson. The remaining stalk bases were taken to Manhattan, Kansas to be overwintered under laboratory conditions.

Overwintering Conditions for Experimental Observations in the Field

Three types of soil were selected in the field, (a) light, sandy soil which was well drained, (b) heavy, black soil in a draw and (c) hard packed sandy soil which was well drained. A twelve inch, one bottom, moldboard plow was used by Mr. Baldwin to plow a series of furrows through each of these areas to provide a situation either than ground level (well drained) and one lower than ground level (poorly drained) (Plate V, Fig. 1).

In the light, well drained soil (a), 540 stalk bases were placed. These were divided into four groups, three of which consisted of 180 stalk bases each and one of 90. The group of 90 stalks was buried in a hole two and one-half feet deep and covered with stalk debris, leaves and soil. Of each group of 180 stalk bases, 90 were "transplanted" on the ridge provided by the plow and 90 were "transplanted" in the furrow. The first group of 180 stalk bases (Unit I) was left uncovered. The second group of 180 stalk bases (Unit II) was covered with from six to nine inches of corn stalk debris which was in turn covered with Sisal Craft paper. Holes were punched in the paper to provide air. The covering material was held in place by wire netting staked at the sides and held in place with wires (Plate VI, Fig. 3). The third group of 180 stalk bases (Unit III) was covered with from six to nine inches of corn stalk debris held in place by poles tied together with wires (Plate II, Fig. 4).

In the heavy black soil (b) 270 stalk bases were placed. Of these 180 were placed in the furrow and 90 on the ridge. These

EXPLANATION OF PLATE I

Fig. 1. Ridge and furrow prepared for "transplanting" corn stalk bases infested with the southwestern corn borers in the field at Hutchinson, Kansas. (Photograph by M. McDougal)

Fig. 2. Infested stalk bases placed in upright position after gathering to prevent unnatural disturbance until they were "transplanted". (Photograph by M. McDougal)

PLATE I

Fig. 1

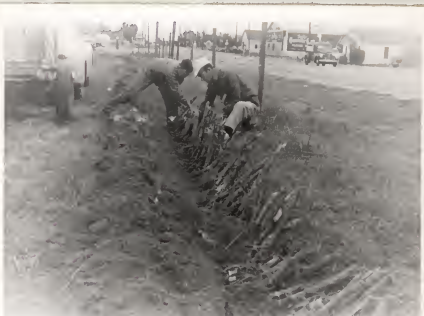


Fig. 2.

were left uncovered (Plate III, Fig. 5).

In the hard packed sandy soil (o) 180 stalk bases were placed. Of these 90 were placed on the ridge and 90 in the furrow. These were not covered.

One third of the material in each unit was examined on April 9, 1943, and records of mortality were made. Various organisms found within the overwintering tunnels were collected. Attempts were made to rear the dipterous insects and pupae recovered. The remainder of the material was examined on June 7, 1943.

Overwintering Conditions for Experimental Observations in the Laboratory

The remainder of the stalk bases which were obtained at Hutchinson were brought to Manhattan and prepared for overwintering in the laboratory under variable conditions. In the laboratory experiments, 460 borers were used. These were divided into three equal units of 120 each. Each unit of 120 borers was in turn divided into three groups A, B, and C of 40 borers each.

Group A was placed in glass tubes, (Plate V) group B was placed in holes which had been bored into a balsa block (Plate VI) and the borers of group C were allowed to remain in the stalk bases (Plate VIII).

The individuals of group A in each unit were weighed, the weight being determined to the nearest 0.2 milligram; then each was placed in a glass tube three inches long and seven millimeters inside diameter. The ends of the tube were then plugged with

EXPLANATION OF PLATE II

Fig. 3. Corn stalk bases infested with the southwestern corn borer "transplanted" in loose soil in the field at Hutchinson, Kansas, being covered with stalk debris and Sisal Craft paper. (Photograph by M. McDougal)

Fig. 4. Corn stalk bases infested with the southwestern corn borer "transplanted" in loose soil in the field at Hutchinson, Kansas, being covered with from six to nine inches of corn stalk debris. (Photograph by M. McDougal)

PLATE II

Fig. 3.

Fig. 4.

EXPLANATION OF PLATE III

Fig. 5. Corn stalk bases, infested with the southwestern corn borer, "transplanted" in heavy black soil in a draw in the field at Hutchinson, Kansas. (Photograph by H. McDougal)

Fig. 6. View of the corn stalk bases in the heavy black soil in a draw (parallel with fence near the center of the picture) covered with drifted snow and ice during the winter. They were under water most of the spring. (Photograph by H. Walkden)

PLATE III

Fig. 5.

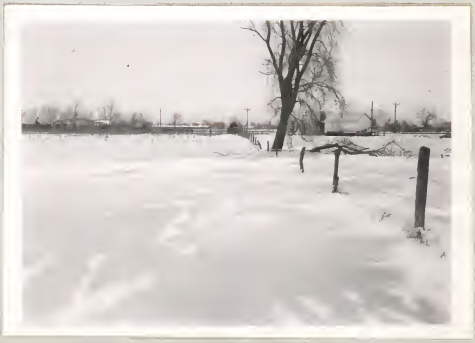


Fig. 6.

EXPLANATION OF PLATE IV

Fig. 7. Corn stalk bases infested with southwestern corn borers "transplanted" in loose, sandy soil in the field at Hutchinson, Kansas, under snow during the winter. The stalk bases were uncovered, covered with Sisal Craft paper and stalk debris and covered with stalk debris only. (Photograph by H. Walkden)

Fig. 8. Same as Fig. 7 viewed from the opposite end. (Photograph by H. Walkden)

PLATE IV

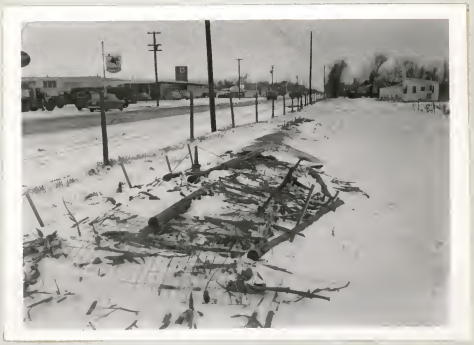


Fig. 7.

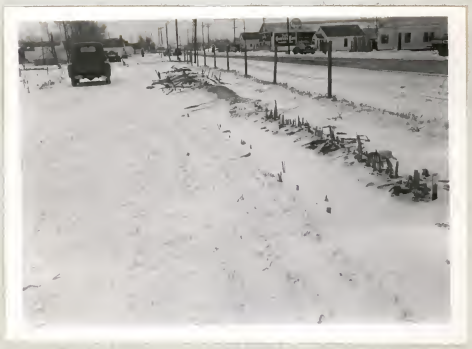


Fig. 8.

cotton and the tube placed upright in a pan of sand. The tubes were held in the upright position by placing them in holes which had been drilled in blocks of wood 4 1/2 inches by 3 1/2 inches by 3/4 inch. The tubes were darkened by inverting a small cardboard box over the group, allowing an air space at the bottom. The sand in the pan was kept moist throughout the experiment to prevent desiccation. O'Kane and Lowry (1927), in rearing European corn borers by a similar method, applied moisture directly to the cotton plug at five to six day intervals.

Those individuals of group B of each unit were likewise weighed and placed head first in a hole 5/16 inch by approximately 2 1/2 inches deep which had been drilled in a balsa wood block 3 inches by 2 1/2 inches by 6 inches. The openings were then plugged with cotton and the block immersed in approximately one inch of water for five minutes. This method of supplying moisture was repeated once each week throughout the overwintering period.

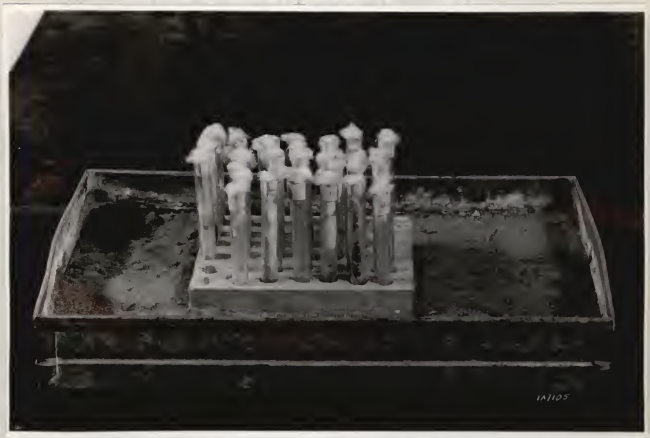
The stalk boxes in which the borers of group C of each unit were situated were tied in bundles of five each and placed with each unit. These were moistened by immersing the bundles in three to four inches of water.

Each unit, consisting of 40 specimens in glass tubes, 40 specimens in the balsa block and 40 specimens in stalk boxes, was then placed in a convenient sized box. These were kept where the temperature did not reach freezing. On January 15, 1947, unit I was placed in an attic room of a stone building (Fairchild Hall) where the average mid-day temperature from January 15 to May 16

EXPLANATION OF PLATE V

Glass tubes, held upright by a wood block, in a pan of sand in which southwestern corn borers were overwintered in the laboratory at Manhattan, Kansas. (Photograph by F. J. Hanne)

PLATE V



EXPLANATION OF PLATE VI

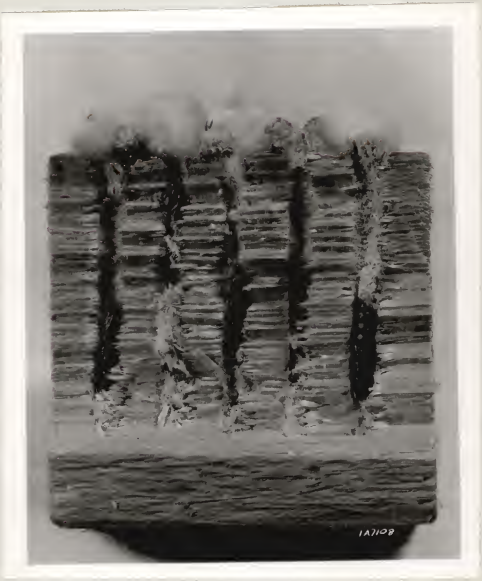
Balsa wood block in which southwestern corn borers were overwintered in the laboratory at Manhattan, Kansas. The cotton plugs are to prevent escape of the borers. (Photograph by F. J. Hanna)

PLATE VI

EXPLANATION OF PLATE VII

Balsa block in which southwestern corn borers were overwintered in the laboratory at Manhattan, Kansas. This block has been cut open after emergence of the moths to show the empty pupal cases in the overwintering cells. Note the frass in the tunnels. (Photograph by J. J. Hanna)

PLATE VII



EXPLANATION OF PLATE VIII

A bundle of infested corn stalk bases in which southwestern corn borers were overwintered in the laboratory at Manhattan, Kansas. (Photograph by F. J. Hanna)

PLATE VIII

was about 64° F., the range being from 59° F. to 82° F. Unit II was placed in an underground cave where the average temperature for the same period was about 48° F., the range being from 46° F. to 55° F. Unit III was placed in a fruit storage refrigerator in which the temperature 37° F. remained constant. These units were observed at various times during the overwintering period and the condition of the specimens in the glass tubes was recorded.

On May 16, 1949, each unit was removed from its location and the groups placed separately in a screened cage with a glass front. The cages were placed in a room in which no heat was provided and allowed to remain there throughout emergence of the moths. Oviposition and fertility of the overwintered females was determined by placing 14 moths in a cage with a small corn plant. The egg masses deposited were observed until hatching. Following the period of emergence the balsa blocks and stalk bases were opened and the contents examined.

RESULTS

Field Conditions

Upon examination, on April 9, 1949, of one third of the material which was being overwintered under field conditions, indication of a high mortality rate in all units was evident. Only 4.5 percent or 15 living specimens out of 330 infested

stalks were recovered.[1] The majority of the living borers were recovered from those stalk bases provided with cover (Table 1). Six specimens were recovered from unit II, (covered with stalk debris and Sisal Craft paper) and seven were recovered from unit III,(covered with stalk debris only). Unit II, furrow, yielded one living specimen and unit II, ridge, yielded five. Six living borers were recovered from unit III, furrow, while only one was recovered from the ridge. There is no explanation for this occurrence.

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1. These stalks were presumed to be infested. All were girdled which is the best means of determining infestation without destroying the stalk.

Table 1. Mortality record of southwestern corn borers overwintered in stalk bases under modified field conditions at Hutchinson, Kansas from October 1948 to April 9, 1949.

Unit		Level	Number stalk bases examined	Alive Apr. 9, 1949	Dead Apr. 9, 1949	Missing Apr. 9, 1949
				Number		
I	Uncovered	furrow	30		24	6
		ridge	30		25	5
II	Covered with stalks and paper	furrow	30	1	25	4
		ridge	30	5	24	2
III	Covered with stalks	furrow	30	6	20	4
		ridge	30	1	28	2
IV	Uncovered	furrow	30		26	4
		ridge	30		22	8
V	Uncovered	furrow	30	2	26	2
VI	Uncovered	furrow	30		27	4
		ridge	30		20	10
(All units)			330	15	267	51

From Table 2, it can be seen that the mortality of the overwintering borers in the field was extremely high. Only three living borers out of a total of 660 were recovered from all units in the examination on June 9, 1949. This represents a mortality of over 99.5 percent. The check area in an adjoining corn field showed a mortality of 99.5 percent on March 22, 1949

as determined by Mr. Herbert H. Walkden.

Table 2. Mortality record of southwestern corn borers overwintered in stalk bases under modified field conditions at Hutchinson, Kansas from October 1948 to June 9, 1949.

Unit		Level	Number stalk bases examined	Alive June 9, 1949 Number	Dead June 9, 1949
I	Uncovered	furrow	60		60
		ridge	60		60
II	Covered with stalks and paper	furrow	60	1	59
		ridge	60		60
III	Covered with stalks	furrow	60		60
		ridge	60	2	58
IV	Uncovered	furrow	60		60
		ridge	60		60
V	Uncovered	furrow	60		60
VI	Uncovered	furrow	60		60
		ridge	60		60
(All units)			660	3	157

Due to the small number of borers recovered from all units it virtually impossible to determine which method of proposed protection afforded the best overwintering condition. It can be seen in Table 2 that two of the borers recovered on June 9, 1949 from unit III, ridge, which was covered with from six to nine

inches of corn stalk debris. Based upon 60 specimens this represents a percentage of 3.4 borers from this unit which were still alive on June 9, 1949. In comparison, to 0.5 percent alive at that time in all units on June 9, 1949 and to 0.5 percent alive on March 22, 1949 in the check area, this type of cover shows slight improvement over nature. The stalk bases were just starting to decompose in unit III at the June 9 inspection. It is of interest that the other borer recovered on June 9 was taken from unit II, furrow, which was provided with a cover of stalk debris and Sisal Craft paper. The stalk bases in this situation were very soft and well decomposed. It is of further interest that the group of 50 stalk bases which were buried two and one half feet in the ground and covered with stalk debris, boards and soil were so badly rotted that only 27 stalk bases were distinguishable; however three borers appeared only recently dead.

The condition of the stalks in all units ranged from dry and hard to soggy and decomposed. Various organisms were found within the overwintering cells. Those found most commonly were mites, collembolans, dipterous larvae and various fungi. Unit VI, which was placed in hard-packed, sandy, dry soil, was heavily infested with termites. The Diptera larvae were reared in the laboratory; they were identified as follows: Fungivoridae, Bradysia sp., determined by Alan Stone, Forcipomyia texana (Long)? (this species usually has been found breeding under bark of trees) and Otitidae, Chaetopsis fulvifrons (Macq.) determined by Willis W. Wirth.

Laboratory Conditions

The methods used to overwinter the southwestern corn borers in the laboratory produced considerably better results than the methods used in the field (Table 3). One hundred and ninety-five moths were recovered from 360 borers which were overwintered in the laboratory. Eighty-two moths were recovered from 120 borers which were overwintered in the attic room. Eighty-one moths were recovered from 120 borers overwintered in the fruit storage refrigerator. The temperature was higher in the attic room and cave than in the fruit storage refrigerator.

In comparing the balsa blocks, glass tubes, and stalk bases from the attic room, cave and fruit storage refrigerator, it was found that the balsa blocks produced the highest number of living moths and the glass tubes produced the lowest number of living moths, (Table 4). Since the selection of infested stalk bases was not always possible this leads a discrepancy to the comparison of stalk bases with balsa blocks or glass tubes as a material in which to overwinter the borers.

On September 29, 1949, one living borer was recovered from the balsa block and one from a stalk bases of the material overwintered in the fruit storage refrigerator (temperature 37° F.).

Little information of value to one interested in overwintering borers of the southwestern corn borer was determined from studies dealing with the relation of weight to survival and death. The average weight of those which died was slightly

Table 3. Effects of warm, medium and cold environments on southwestern corn borers overwintered under laboratory conditions at Manhattan, Kansas from the fall of 1948 to the summer of 1949.

Environment of borers during overwintering period	Group	Number in each group	Number emerged	Number dead	Number not evident	Number emerged not normal	Number alive Sept. 29, 1949
I attic room, mid-day temperature range 59° F. to 82° F.	Balsa Block	40	32	8			
	Glass Tubes	40	24	15		1	
	Stalk Bases	40	26	7	7		
	Total	120	82	30	7	1	
II cave, temperature range 46° F. to 55° F.	Balsa Block	40	34	4	2		
	Glass Tubes	40	14	26			
	Stalk Bases	40	33	3	4		
	Total	120	81	33	6		
I II fruit storage refrigerator constant temperature 37° F.	Balsa Block	40	17	22			1
	Glass Tubes	40	6	34			
	Stalk Bases	40	9	29	1		1
	Total	120	32	85	1		2

Table 4. Southwestern corn borers overwintered within cells in balsa blocks, glass tubes and stalk bases in different environments in the laboratory at Manhattan, Kansas from the fall of 1948 to the summer of 1949.

Material in which overwintering cells were located	Environment of borers during overwintering	Number in each group	Number emerged	Number dead	Number emerged not normal	Number not evident	Number alive Sept. 29, 1949
Balsa blocks							
	Attic room	40	32	8			
	Cave	40	34	4		2	
	Fruit storage refrigerator	40	17	22			1
	Total balsa blocks	120	83	34		2	1
Glass Tubes							
	Attic room	40	24	15	1		
	Cave	40	14	26			
	Fruit storage refrigerator	40	6	34			
	Total glass tubes	120	44	75	1		
Stalk Bases							
	Attic room	40	26	7		7	
	Cave	40	33	3		4	
	Fruit storage refrigerator	40	9	29		1	1
	Total stalk bases	120	68	39		12	1

EXPLANATION OF PLATE IX

Fig. 9. Mold covering a dead southwestern corn borer in the overwintering cell of a stalk, taken from the field plots at Hutchinson, Kansas on April 9, 1949. (Photograph by F. J. Hanna)

Fig. 10. An overwintering tunnel of a southwestern corn borer filled with mold. This specimen was taken from the field plots at Hutchinson, Kansas on April 9, 1949. (Photograph by F. J. Hanna)

PLATE IX

Fig. 9.

Fig. 10.

EXPLANATION OF PLATE X

Fig. 11. Dipterous larvae (center) in corn stalk taken from the field plots at Hutchinson, Kansas on April 9, 1949. (Photograph by F. J. Hanna)

Fig. 12. A corn stalk base containing a dead southwestern corn borer covered with mold. This was taken from the field plots on April 9, 1949. (Photograph by F. J. Hanna)

PLATE X

Fig. 11.

Fig. 12.

EXPLANATION OF PLATE XI

A corn stalk base containing a dead southwestern corn borer covered with mites. This was taken from the field plots at Hutchinson, Kansas on April 9, 1949. (Photograph by F. J. Hanna)

PLATE XI

higher than those which emerged. However, 975.0 milligrams is the lightest weight of one which emerged. The heaviest individual which died was 400.4 milligrams and 492.6 milligrams is the heaviest weight of a borer which emerged, see Table 5.

Table 5. Weight ranges of surviving and dead borers which were overwintered in balsa wood blocks from the fall of 1948 to the spring of 1949 at Manhattan, Kansas.

Overwintering habitat :	Borer	: Weight in milligrams	
		: Emerged	Dead
Attic room	lightest borer	112.6	094.4
	heaviest borer	492.6	374.4
Cave	lightest borer	105.0	150.0
	heaviest borer	414.0	400.4
Fruit storage refrigerator	lightest borer	130.4	076.0
	heaviest borer	392.0	386.4

Seasonal Progress of Specimens in Glass Tubes. The progress of the borers in the glass tubes of all units could be observed throughout the overwintering season.

On November 27, the specimens were weighed and placed in the glass tubes. On December 2, these specimens were observed. Seventy-two percent had already spun a silken lining with a cap inside the glass tube. These cells averaged 38 millimeters high from the top of the bottom cotton plug to the silken cap. The shortest one was 16 millimeters and the highest was 60 millimeters. Observation of the specimens on December 13 revealed that 39 percent had molted and an additional 11 percent had spun and capped

a silken cell inside the tube. By December 31, an additional 20 percent had molted bringing the total percentage of those that had molted to 55. By February 16, a total of 73 percent had molted at least once.

Emergence of Moths from Pupae of Successfully Overwintered Borers. By May 3, many of the borers in glass tubes which had spent the winter in the attic room had broken the cell cap, the specimens had begun to shorten and two of the borers had pupated. Four specimens in the balsa block had bored to the surface. The specimens from the cave and the fruit storage refrigerator showed no evidence of preparation to pupate at this time. On May 15, two moths emerged from the balsa block in unit I.

On May 16, all units were placed in the same environment and the balsa blocks, glass tubes, and stalk bases were placed separately in screen cages. By May 17, five moths had emerged from the balsa block and one each from the glass tubes and stalk bases which had spent the winter in the attic room. Emergence of these continued until June 21 when two moths each emerged from the glass tubes and the stalk bases. The last record of emergence from the balsa block was on June 3.

The first emergence of adults from the borers overwintered in the cave was on June 14, when nine moths emerged. Three emerged from the stalk bases and six from the balsa block. The last record of emergence from the specimens overwintered in the cave was on July 1. Emergence of adults from the specimens overwintered in the fruit storage refrigerator did not begin until June 21. Emergence from this unit was completed by July 16.

From observations of the specimens just prior to pupation it seems to be a tendency for them to migrate from the overwintering cell and seek a new environment for pupation. It was noticed in the glass tubes that several borers left the tube to pupate. The specimens in the balsa blocks often bored perpendicular to their overwintering cell. This tendency to migrate prior to pupation apparently does not occur in nature since most of the borers pupate in the overwintering cell. Poos (1927) stated that an unnatural environment as is necessary under laboratory conditions prohibits migration prior to pupation to such an extent that pupation is greatly delayed if not entirely prevented in the rearing of the European corn borer.

Oviposition and Fertility of Eggs from Overwintered Females. On May 23, 14 moths of both sexes were placed in a cage with a corn plant 12 inches high. On May 24, three egg masses were discovered on the leaves of the plant. Two masses on the upper leaf surface contained three and nine eggs respectively; the one mass on the under side contained 11 eggs. Over 100 egg masses were counted on the glass and floor of the cage. On May 26, each egg on the plant was marked with three red stripes. On May 31, the eggs hatched and the small larvae were crawling over the plant.

CONCLUSIONS

The following conclusions can be drawn from the experiments conducted on overwintering of southwestern corn borers under

modified field conditions at Hutchinson, Kansas.

1. The methods used to overwinter the southwestern corn borer in the field had little advantage over nature.

2. Most of the borers recovered in the field experiments were taken from material which had been covered with corn stalk debris, and corn stalk debris and Sisal Craft paper. This would indicate that such cover is an advantage to the borer. However, the number of borers recovered on June 9 was too small to concluded that this method of protection is better than nature.

3. The number of living borers recovered from the experimental field plots on June 9, 1949 was insufficient to determine the value of any method of field modification attempted as a means of overwintering the borers.

The following conclusions can be drawn from the experiments conducted on overwintering of southwestern corn borers under laboratory conditions at Manhattan, Kansas.

1. Southwestern corn borers were successfully overwintered in the laboratory.

2. Successful overwintering was more dependent upon temperature upon the material in which they were overwintered. Temperatures between 45° F. and 82° F. appeared favorable for overwintering borers in the laboratory. As the temperature approached freezing, overwintering was less successful.

3. The largest number of moths was recovered from borers which had been overwintered in balsa wood blocks; however the corn stalk borers were only slightly less efficient and for production of large numbers of moths would require much less

preparation.

4. The weight of the borers at the time of preparation for the overwintering period showed no relation to the number of moths recovered in these experiments.

SUMMARY

Due to the small number of overwintering southwestern corn borers, Diatraea grandiosella Dyar, which emerge normally as adult moths in Kansas, the development of a method for overwintering larger numbers of moths would facilitate experimental study of the first generation borers.

Since the southwestern corn borer is not present in quantities in the Manhattan, Kansas area, infested stalk bases for this work were obtained from the Bureau of Entomology and Plant Quarantine at Hutchinson in Reno county, Kansas. These stalks were divided into two lots of 1040 and 440, respectively. The first lot was divided into six units and placed in various modified ecological situations in the Bureau of Entomology and Plant Quarantine experimental field at Hutchinson. One third of this material was examined on April 9, and the remaining two thirds was examined on June 9, 1942, to determine winter mortality. A check area was left undisturbed in a nearby field.

The second lot of stalk bases was brought to Manhattan and prepared for overwintering under laboratory conditions. In the laboratory the specimens were divided into three units. Each unit consisted of an equal group of specimens in holes in balsa

wood blocks, in glass tubing, and in stalk bases. Each unit was placed in a situation in which the temperature from January 15 to May 16 was different. At the beginning of the pupal period the groups from all units were caged separately in the same environment. Emergence of adults from each group was observed and the moths recovered.

The methods used to modify the overwintering conditions of the southwestern corn borer in the field had little advantage over natural conditions. The number of living borers recovered was insufficient in all cases to determine the value of any method of modification as a means of overwintering the borers. Most of the borers which were recovered at the April 9 inspection and all recovered at the June 9 inspection were taken from material which had been covered. This would indicate that such protection is an advantage to the borer. However, the number of living borers recovered at the June 9 inspection is too small to concluded that this method of protection is better than nature.

The methods used to overwinter the borers in the laboratory were considerably more successful than the field conditions. As many as 85 percent were successfully overwintered. The emergence of the borers was more dependent upon temperature than upon the materiel in which they were overwintered. Balsa wood blocks yielded the highest number of living moths; however the stalk bases were only slightly lower. For the production of a large number of moths, the stalk bases would require much less time to prepare for overwintering than the other methods tried. The use

of stalk bases would require more discretion in gathering material to assure that infested material was obtained.

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