THE OVIPOSITION AND LARVAL HABITS OF
Diatraea grandiosella Dyar IN OKLAHOMA

By

SESS D. HENSLEY

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Thesis Approved:

D E Howell
Thesis Adviser

R R Walton
Member of the Thesis Committee

D E Bryan
Member of the Thesis Committee

James S Brooks
Member of the Thesis Committee

K.D. Arbuthnot
Member of the Thesis Committee

D E Howell
Head of the Department

Robert MacVicar
Dean of the Graduate School

PREFACE

Studies on resistance of corn to the southwestern corn borer have been in progress at the Oklahoma Agricultural Experiment Station or its substations for the past decade. While differences in degree of resistance have been found in some corn lines, no major sources of resistant germ plasm have been identified. It was suggested by Mr. K. D. Arbuthnot, Entomology Research Branch, United States Department of Agriculture, that perhaps a better approach to plant resistance could be made by a more thorough study of the oviposition and larval habits of the southwestern corn borer. This the writer has endeavored to do by making a detailed study of these and related biological phenomena. Data were taken from corn fields at the Agronomy Farm, Oklahoma A. & M. College and from other fields in the vicinity of Stillwater during the period June, 1953 to September, 1954.

Valuable assistance in this study was provided by several individuals and organizations at Oklahoma A. & M. College. Dr. D. E. Howell, Head of the Department of Entomology, served as chairman of the writer's graduate committee and gave valuable counsel on experimental procedures and manuscript preparation. Mr. K. D. Arbuthnot, Entomology Research Branch, United States Department of Agriculture was instrumental in initiating the study and in supervising field research. Dr. J. S. Brooks of the Department of Agronomy provided plots of corn for the study and gave valuable information on its agronomic aspects. Drs. D. E. Bryan and R. R. Walton, Department of

Entomology, gave critical advice on preparation of the manuscript. B. H. Kantack, graduate student, Department of Entomology assisted in taking data. The Department of Entomology provided laboratory facilities and equipment. Cultivation of the corn plots was done by personnel of the Department of Agronomy, and monetary assistance and transportation was provided by the Entomology Research Branch, United States Department of Agriculture.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

Table		Page

CHAPTER I

INTRODUCTION

Diatraea grandiosella Dyar the southwestern corn borer, belongs to the genus Diatraea, subfamily Crambinae and family Pyralididae. The genus Diatraea includes a large number of moths whose larvae are borers in the stalks of graminaceous and cyperaceous plants. At present about 90 species are known throughout the tropical and subtropical regions of the world with approximately 45 species recognized in the western hemisphere. D. lineolata Walker is the most widely distributed of the American species, but its range does not include the United States. D. saccharalis Fabr. is present in the United States only in the subtropical regions of southern Florida, Louisiana and Texas where it is a pest of importance only on sugar cane. D. crambidoides Grote is of some economic importance in the southeastern states as a pest of corn. D. lisetta Dyar, D. venosalis Dyar and D. evanescens Dyar have been reported from the southern regions of the United States but are of relatively little importance as pests of commercial crops.

D. grandiosella apparently is the most important species found in the United States. Presumably introduced into this country from Mexico prior to 1911, the southwestern corn borer has wrought havoc to corn grown throughout the southwestern states and has been reported as far north as Nebraska. At this date its distribution is apparently extending eastward in Arkansas and Missouri. Although the genus is considered to be tropical or subtropical in distribution, there are some indications that _D. grandiosella_ has become adapted to cooler climates. At present this insect appears to be the most important field corn pest found in Oklahoma.

The southwestern corn borer was found in only two counties of Oklahoma in 1930, but by 1953 it had been reported from every county in the state. Indications are that densities of borer populations within fields have also risen sharply since 1950. Prior to 1948 Payne County records show that less than 50 per cent of stalks in fields were infested with borers and that in 1945 there was an average of 2.2 borers per infested stalk. However, since 1950, 100 per cent stalk infestation has been noted and in 1953 a maximum of 11.2 borers per stalk was reported.

An adequate control for southwestern corn borer has not been discovered. Cultural methods tested include date of planting tests, seed bed preparation, increased use of fertilizer and plowing under of stubble in the fall to kill overwintering borers. Each is effective in reducing damage, but any one or any combination of methods does not provide a satisfactory control. Of the chemical controls tested, a few have been effective in reducing borer populations, but in these cases the expense involved in labor, application and cost of insecticide prohibit their use by corn growers.

Losses from southwestern corn borer damage in the Southwestern United States were estimated at two million dollars in 1942 and as 22 million in 1951. Faced with these mounting losses, farmers in Oklahoma have greatly reduced the acreage annually planted to corn.

REVIEW OF THE LITERATURE

Synonymy

Diatraea grandiosella was described by H. G. Dyar in 1911 from a single female specimen collected at Guadalajara, Mexico (Dyar, 1911). A redescription of the adult and the first description of the larvae were presented by Dyar and Heinrich (1927). There are no synonyms listed in the literature.

Confusion with other species of *Diatraea*

During the interval between the two descriptions of *D. grandiosella*, 1911-1927, the species was apparently referred to erroneously as either *D. lineolata* Walker (Morrill, 1915; Vorhies, 1919; Glick, 1922; Howard, 1923; Van Zwaluwenberg, 1923; Caffrey and Worthley, 1923) or *Diatraea zeacolella* Dyar (Morrill, 1916; Leiby, 1920; Ellis, 1925). Apparently these two species did not occur in the states of Texas, Arizona and New Mexico from which they were reported during the period 1915-1925 since Box (1931) noted that *D. lineolata* was not found farther north than central Mexico and that *D. zeacolella* was synonymous to *D. crambidoides* Grote and limited in distribution to the southeastern United States. Davis, et al., (1933) also showed *D. grandiosella* was the only species of *Diatraea* found on corn in the Southwestern United States and that its distribution did not overlap with any other species of the genus known in this country.

Distribution in the United States

Davis, et al., (1933) suggested that *D. grandiosella* could have infested corn grown by Indians in the Southwestern United States before white men settled there. Todd and Thomas (1930) and Davis, et al., (1933) indicated that the species spread from Mexico to the United States at some unknown time in the past. These authors believed the insect spread northward into the United States along river valleys of the Trans Pecos area of Texas where corn was grown but that it was unable to extend eastward from this area because of the absence of corn in the arid areas between the river valleys.

Todd and Thomas (1930) were the first to report D. grandiosella in the United States. They stated that it had been present in this country for at least 10 years and reported in the literature erroneously as other species of Diatraea.

Davis, et al., (1933) gave the known geographical distribution of D. grandiosella in the United States in 1931 as the southeastern corner of Arizona, nearly the southeastern two-thirds of New Mexico, most of the Panhandle and Big Bend districts of Texas, about two-thirds of the Oklahoma Panhandle, the extreme southwestern corner of Kansas and the extreme southeastern corner of Colorado. Colorado has since been deleted from the area of known distribution (Cooperative Economic Insect Report, 1955).

Apparently D. grandiosella extended its distribution eastward from the Oklahoma and Texas Panhandle districts, for in 1937 it was reported in north central Texas (Thomas and McGregor, 1937) and in west central Oklahoma (Records on file Entomology Dept., Oklahoma A. & M. College). Fenton (1941) reported it from Harmon, Grant, Caddo, Woodward and Woods counties in Oklahoma which indicated it had spread over the western third of the State. Walton (1945) reported the southwestern corn borer as generally distributed over the western two-thirds of Oklahoma and Stiles and Hixson (1946) reported it as occurring in three-fifths of the state.

D. grandiosella was reported in 29 southwestern counties of Kansas in 1941 (Wilbur, et al., 1942) (Wilbur and Bryson, 1942) Wilbur, et al., (1950) stated that possibly a light infestation had occurred in Kansas in 1940. Smith (1942) stated "E. G. Kelly found typical damaged corn in Douglas County near Shawnee in 1941. It is believed that these, the larvae in this case, were D. crambidoides." Douglas County is at least 100 miles east of the known distribution of D. grandiosella in 1941. Wilbur (1945) stated that the southwestern corn borer following several years of drought apparently moved eastward towards central Texas, then northward across Oklahoma into south central Kansas, and that this entire movement may have occurred in the summer of 1941 or at least during the summers of 1941 and 1942. It was indicated (Wilbur, et al., 1950) that the southwestern corn borer apparently was not found in Kansas several years prior to 1941 because of drought. Fifty-one counties in 1942, 61 in 1943 and 63 in 1944 were reported infested as D. grandiosella continued to spread in a northeasterly direction across Kansas.

Tate and Bare (1945) reported D. grandiosella in three south central counties of Nebraska in 1943. Tate and Bare (1946) indicated this distribution did not increase in 1944 or 1945 and that apparently low temperatures in that area would limit its northward spread. It has not been reported from Nebraska since 1945.

In 1949, D. grandiosella was reported from Sebastian County, Arkansas (Walkden and White, 1950) and in 1950 from Franklin County, Missouri (Walkden and White, 1951). These are the first records of the insect in these states. Records of the Entomology Department, Oklahoma A. & M. College show that by 1953 the southwestern corn borer had been reported from every county in Oklahoma.

The known distribution of D. grandiosella in the United States in 1954 (Cooperative Economic Insect Report, 1955) is approximately as follows: The southern half of Airzona, the southern half of New Mexico, 61 counties in the western half and 15 in the eastern half of Texas, all of Oklahoma, all of Kansas except six northwestern and four northeastern counties, 25 counties in western Missouri and 23 counties in eastern Arkansas. Apparently it is continuing to spread eastward in Arkansas and Missouri.

This distribution overlaps with that published for D. crambidoides in Kansas which was described from that State by Grote in 1880 (Box, 1931) and reported from there under the synomym D. zeacolella (Dyar and Heinrich, 1927) and as possibly found there in 1941 (Smith, 1942). These reports are the only ones in the literature referring to the occurrence of D. crambidoides in Kansas, however, it was reported from Racine, Wisconsin in 1927 as D. zeacotella (sic), (Drake and Decker, 1927).

In Texas the eastern distribution of D. grandiosella is contiguous with the western distribution of D. saccharalis since these species have been reported as occurring in adjoining counties; D. grandiosella in Cherokee County (U.S.D.A. Cooperative Insect Report of 1955) and D. saccharalis in Angelina County (Holloway and Loftin 1919; Holloway, et al., 1928).

Taxonomy

It is difficult to differentiate species of Diatraea. The similarity of larvae of several species apparently prohibits the use of this stage for specific identification. Dyar and Heinrich (1927) reported that larval characteristics could not be used to separate all species of Diatraea. Box (1931) uses only adult characteristics in his key to the species of Diatraea. He also indicates that because of the great variation found in individuals within each of several species, positive identification in many cases can be made only by examination of the internal structure of the genitalia. Peterson (1948) presented a key for the preparation of larvae of D. grandiosella, D. crambidoides and D. saccharalis, however, he indicated (personal communication) that this key may not be valid for all variations of characteristics.

The overwintering larvae of D. grandiosella were described in Arizona (Davis, et al., 1933) as being creamy white, having molted from the spotted summer form. A similar overwintering form is reported for D. crambidoides in the Southeastern United States (Lieby, 1920). These authors associate the change of spotted (summer form) larvae to white (winter form) with the advent of cooler temperatures in the fall of the year. Kevan (1943) and Painter (1955) reported that D. lineolata has a white resting stage in dry or mature corn in tropical South America. Kevan (1944) reported this stage occurred between rainy seasons and that contact moisture was necessary before larvae would transform into the pupal stage.

Davis, et al., (1933) described D. *grandiosella* eggs in late stages of development as having three distinct red transverse bars. Similar barring is described for eggs of D. *lineolata* (Kevan, 1944). Eggs of D. *saccharalis* (Holloway, et al., 1928) and D. *crambidoides* (Leiby, 1920) are reported as having red or orange splotched appearances during the latter part of their development, but no mention is made of bars.

Life history

Davis, et al., (1933) presented a thorough report on the life cycle of D. *grandiosella* in Arizona. Briefly their observations were: The species overwinters as immaculate (winter form) larvae in the crowns of unplowed corn stubble. Pupation occurs in April and lasts approximately 11 days. Mating occurs usually the first night after emergence and oviposition usually begins the second night. The moths are nocturnal and deposit eggs in masses of from one to nine or more on leaves and internodes of corn. The eggs hatch in approximately five days and the first generation larvae develop upon and within corn plants approximately one month before pupating. Emergence occurs within tunnels in plants in late June and July. The second generation cycle is approximately the same except that some larvae pupate and emerge to produce a partial third generation in late Aug. and September while others, in some cases in the same stalk, tunnel to the crowns and enter winter quarters as the overwintering brood. Few of the partial third generation are able to survive apparently because of their inability to penetrate the older tougher corn stalks and none were observed to pupate and emerge as a fourth generation.

Five to seven larval molts are described for the summer form spotted larvae and eight to ten for the winter form immaculate larvae.

Two and a partial third generations of D. grandiosella were reported in Texas (Thomas and McGregor, 1937) and in Oklahoma (Walton and Bieberdorf, 1948), but Wilbur, et al., (1950) reported only two generations in Kansas.

Injury to corn plants

Davis, et al., (1933) indicated that corn was injured by D. grandiosella in the following ways - feeding of early instar larvae in whorls of young plants, tunneling and feeding of later instar larvae within stalks, ear shanks and ears, and by internal girdling of stalks near the ground level by larvae preparing to overwinter in the fall. These authors reported that about half of the infested stalks in Arizona were girdled during a period of several years prior to 1931. Wilbur, et al., (1950) indicated that the amount of girdling varies within fields and between years.

Food plants

Todd and Thomas (1930) listed food plants of D. grandiosella in northwest Texas as; corn, milo, feterita, hegari, and orangetop cane. Davis, et al., (1933) listed corn, grain sorghums, sugar cane, broom corn and Johnson grass as attacked by D. grandiosella, but stated that only corn was severely injured. Walton and Bieberdorf (1948) listed Sudan grass also as a food plant.

Parasites and predators

Davis, et al., (1933) listed Trichogramma minutum Riley and Apanteles diatraeae Muesebeck as parasites and Solenopsis geminata var. diabola Whrl. as a predator of D. grandiosella. Noble and Hunt (1937) found that Exeristes roborator (F.) parasitized the larvae of D. grandiosella. It was found in the summer of 1954 (Hensley and Arbuthnot, 1955) that Chelonus annulipes Wesm. would parasitize D. grandiosella under laboratory conditions. Field releases of this Braconid species were made near green corn fields at Stillwater and Bixby, Oklahoma. As of this writing the parasite has not been recovered in the field.

CHAPTER III

METHODS AND MATERIALS

A study was made at the Agronomy Farm, Oklahoma A. & M. College during 1954 of the oviposition and larval habits of the southwestern corn borer. An attempt was made to find and record all borer eggs throughout the growing season, deposited on certain plants selected for study. These plants were dissected at periodic intervals from June 7 to September 5 and the number, instar and location of larvae found within or upon plants were recorded. Seasonal history data incidental to the study were also taken throughout the growing season from other fields of corn in the Stillwater area. Corn in this area was affected severely by drought during June, July, and August of 1954. The plantings in which this study was made were not irrigated and by mid-July the plants were suffering greatly from lack of moisture. By mid-August most of the plants had died from drought injury. Data relating to the southwestern corn borer taken during July and August apparently are of little value except to indicate the survival potential of the southwestern corn borer when subjected to extremely dry conditions.

Field layout

Two single crosses of corn were used in this study. The OK12xCI7 cross was assumed, on the basis of earlier tests, to show some resistance to attack by the southwestern corn borer. The other cross, K4xK201, was assumed, on the same basis, to be susceptible to the borer. The two crosses were planted in adjacent blocks on each of two planting dates. The first planting for study of the first generation of the borer was made April 2. It consisted of 10 rows of each cross. Row length was approximately 150 feet, spacing between rows 42 inches and spacing between plants approximately one foot after thinning. The second planting, approximately one-fourth mile south of the first, was made at a later date (May 20) on the assumption that it would escape most of the first generation infestation and be at the right stage of growth to become heavily infested with second generation borers. This planting consisted of three rows of each cross. Row length was approximately 600 feet, spacing between rows 42 inches and plant spacing one foot after thinning.

The planting and cultivation of corn used in this study was the responsibility of the Agronomy Department. Both crosses received the same cultural treatment throughout the season.

Selecting and tagging plants

Prior to this study it was found that in this area usually less than 50 per cent of the corn stalks in any given field become infested with first generation southwestern corn borers and these infestations might occur anywhere within a field. For this reason it was decided to select and tag a corn plant for observations approximately every 10 feet of row space in the early planting so that data would be taken throughout the field. This procedure was also followed in tagging plants in the later planting with the exception that row spacing between tagged plants was approximately 20 feet.

Three hundred plants in the April 2 planting were selected and tagged May 19 for the first generation study of the borer and 180 plants were tagged June 14 for the second generation study. Plant height in the early planting, averaged only one foot when the first eggs were observed on plants (May 19) and it was necessary to begin observations for eggs. In order to avoid interferring with the growth of the unfurling whorled leaves, tags, at this time were attached to the stalks at ground-level and later moved 18 inches higher on the plants. In the later planting, the plants were approximately four feet tall and tags were attached at 18 inches above ground-level. Weather-proofed paper tags were attached by means of a loose wire loop around the stalk to avoid binding and girdling the plant. Row number and plant number within rows were written on each tag as a means of locating plants during examination.

Marking and recording egg masses

A record was kept of the fate of individual eggs found on tagged plants. In order to do this it was necessary to record the date each egg mass was observed deposited, the number of eggs it contained and its location on the plant, and, on subsequent observations to determine, whether it had hatched, was parasitized, eaten, lost or infertile. The oviposition period of this insect lasts approximately one month during the first generation and continues throughout the summer during second and partial third generations (Davis, et al., 1933). Therefore, corn plant surfaces on which egg masses were found had to be marked in such a manner that each mass would not be confused with any other mass found on the same plant. The method of marking also had to be durable enough to remain legible for a period of a month or more.

After experimenting with several means of marking plant surfaces it was found that a ball point pen served the purpose best. This type pen did not injure the plant surfaces appreciably. Its ink remained legible for approximately 45 days withstanding fading by rain and sun, and the procedure was fast and simple as compared with brushes, marking fluid and containers used in other methods.

Southwestern corn borer eggs are easily seen on corn plants. They are transluscent white when first deposited, change to creamy white in a matter of hours and the appearance of three laterally transverse bars is noted usually within 24 hours after deposition. Individual egg size averages 1.3 mm. in length and 0.8 mm. in width. The dorsal surface of the egg after deposition is slightly convex and the ventral surface assumes the contour of the surface upon which it is deposited. Eggs are deposited in masses of one to nine or more (Davis, et al., 1933).

During observations, when an egg was found on a tagged plant a small circle was drawn around it and a number written near it on the plant. The masses found were numbered chronologically on each plant and their corresponding numbers written in a field notebook. Data for each tagged plant were recorded separately in the notebook. They included the numbers corresponding to egg masses, the location, number of eggs and date of observed deposition of each mass and on subsequent observations, its fate, i.e., whether it had hatched, was parasitized, eaten, infertile or lost.

Observing plants for egg masses

Plants taken at random were observed in both plantings daily until eggs were found. A first generation egg mass was found on an untagged plant in the early planting on May 18 and examination of tagged plants for egg masses was started on May 20. The earliest second generation eggs were observed in the later planting on June 29 and examination of tagged plants started the next day.

Nine observations for eggs on the 300 tagged plants in the early planting were made semi-weekly (3-4 day intervals) during the period May 20 to June 18. Eight observations were made in the later planting during the period of June 15 to July 23.

When examining tagged plants for eggs, on each observation date, all parts of the plant above ground: Stalk, leaf sheaths, ligules, upper and lower leaf surfaces and ears and ear shoots, if present, were scanned thoroughly. The egg masses found were marked and recorded according to their specific location on the plant. Each of these plants could be examined in about two minutes. However, about four minutes was required for examination of each plant in the later planting during second generation egg deposition because the plants were much larger, ranging in height from four feet (June 30) to six feet (July 30) and their leaves were ragged from insect feeding and wind damage. They also wilted during warmer periods of the day which made scanning more difficult. Many more eggs were found and recording them required more time. Apparently the period of second generation egg deposition (June 15 to July 23) was shortened because of the extremely dry weather which occurred during the latter part of June and throughout July and August. By July 15 most of the plants in both fields had turned brown and were dying from lack of moisture. During this entire study, egg deposition occurred only on green parts of plants. Few eggs were found after July 15.

An attempt was made to give the same observational treatment to both crosses of corn at all times. When observing plants on any day a row of one cross was examined and then a row of the other, thus alternating rows between crosses until the observations were completed. By doing this it was believed that if eggs were overlooked because of poor light, fatigue of the observer or other factors, that resulting errors would be equalized between crosses.

Selection and dissection of plants

Tagged plants in the early planting were selected for dissection by taking one plant from each row on seven dates during the period June 7-30. Thus 10 plants from each cross or a total of 140 plants were dissected. Only plants known to have had eggs deposited on them were dissected during the first two dissection dates. However, when it became apparent that many of the plants would not receive first generation eggs, the remaining five dissections were made from plants randomly selected from each row. Many of these plants had no record of egg deposition, however this served as a check on whether eggs had been overlooked during plant observations. The 160 plants remaining in this planting were saved for a study of the borer throughout the growing season, but by the latter part of July it was apparent they would not survive the drought so they were dissected as quickly as possible. Little data were recorded from these plants for few larvae were found, indicating that many had apparently died from lack of moisture or food in the dry plants.

The 180 plants of the late planting were selected at random for dissection. Ten plants from each cross were dissected on each of nine dates during the period July 14 to September 2. On July 14, when the first dissection was made, many dead, first and second instar larvae were taken from the drought injured stalks indicating that few would survive to maturity. Since it was obvious that data taken from this planting would be of little value in showing the location of larvae within plants, it was decided to study the survival of the larvae in corn dying from a lack of moisture. On September 2 when the last dissection was made all tagged and untagged plants in this planting had lodged as a result of the drought.

Plants selected for dissection were dug from the ground with a shovel and transported to a laboratory room and carefully dissected node by node. A careful search was made of the crown, stalk, leaves, leaf sheaths, ligules and ear shoots, ears and tassels if present, for all stages of the borer which were recorded according to the location in or on the specific part of the plant on which they were found. The crown is designated as the under-ground part of the stem and not a part of the root system of the corn plant (Kiesselbach, 1949). The few recorded egg masses found unhatched on plants at time of dissection were deleted from that part of the data relating to survival. Early instar larvae found in unopened whorls were recorded as located in these whorls in the cases where the specific leaf numbers could not be determined. In this study few larvae were found outside plant tissue and it is thought that few if any were lost during transportation of plants to the laboratory.

CHAPTER IV

RESULTS

Seasonal history

Overwintering Brood: Data taken on pupation and emergence of the 1953-54 overwintering brood of D. grandiosella at the Paradise Farm, nine miles south and six miles west of Stillwater are presented in Table 1. By April 26, 39.2 per cent of the overwintering larvae found in corn stubble that had been left standing in the field from last year's crop had pupated. First moth emergence was noted on May 10 when 8 per cent had emerged. By May 17 apparently all of the overwintering larvae had pupated and 22 per cent of the moths had emerged. Moth emergence was 87.5 per cent on May 17, when observations were discontinued because the field was plowed and the corn stubble turned under.

First Generation: First generation eggs were found in the early planting May 18. Plants selected for the study in this field were examined for eggs from May 20 until June 23 when none were found. Data taken during this period are presented graphically in Figure 1 with the number of eggs found on each single-cross and on both crosses plotted as 3 curves.

Two hundred egg masses containing 673 eggs were found on 147 of 300 corn plants observed during this period. The percentages of eggs hatched and parasitized were 90.2 and 1.8, respectively. Trichogramma minutum Riley was the only parasite found during the entire study. Five and four-tenths per cent of the eggs found could not be accounted for during subsequent observations and were listed as lost. Two and two-thirds per cent of the eggs were infertile. However, it is possible that more infertile eggs were deposited than the records indicate since plant examinations were made at 3-4 day intervals and it is believed that some infertile eggs were not found because they only remained on the plants a few hours after deposition.

Seasonal history data (Table 2) taken on the development and pupation of D. grandiosella larvae were accumulated by recording the stage of development of forms found in corn plants from several fields in the vicinity of Stillwater. These fields were subjected to various growing conditions: Some had been planted early, others late; irrigation was used in some fields and not in others. No attempt was made to show the level of infestation that occurred in any particular field but rather to show the general development of D. grandiosella as it occurred in this area during the 1954 growing season. For these reasons records were not kept on the number of stalks infested or number of forms found in each stalk. An attempt was made to dissect enough stalks on each observation date to obtain a record of 100 forms, however, this was not possible in all cases because of the low populations of borers found in some drought-damaged fields.

The earliest record of first generation, first instar larvae was obtained June 1 (Table 2), but approximately 69 per cent of the larvae found in the plants dissected were either second or third instars so it is apparent that this field had been infested several days earlier. The earliest first generation pupation (Table 2) was noted June 23 and on June 29, 54 per cent pupation was recorded. First generation moth emergence was not recorded until July 2. This is not entirely consistent with the second generation oviposition cycle (Figure 2) since eggs were observed on plants June 30. However, as indicated in Table 2, apparently larval development and moth emergence vary considerably within fields and from field to field. Also, it is indicated that larvae of both generations were not found simultaneously until about July 5. The fourth, fifth, and sixth instar larvae and pupae found on this date apparently were of the first generation and the first instar larvae were second generation forms.

Second Generation: Second generation eggs (Figure 2) were first recorded June 30 and none were found July 23. During this period 753 masses containing 1,600 eggs were found on 180 plants all of which received some eggs. The percentage of hatch was 67.8 (Table 7) and 18.3 per cent were parasitized by Trichogramma minutum Riley. Probably the rather high percentage (18.3) of parasitization of second generation eggs was of minor importance in reducing infestation because several unparasitized egg masses were usually found on plants in addition to parasitized eggs. Only a few eggs in each generation were recorded as eaten by predators but more may have been destroyed in this manner and recorded as lost because some eggs may have been consumed to the extent that the remnants were not found.

The earliest record of second generation first instar larvae was obtained July 2 (Table 2). From then until the end of the growing season it was impossible to record separately the generations of D. grandiosella because development of larvae was different in corn subjected to various growing conditions. Non-irrigated corn at Stillwater became a total loss because of drought by mid-August and contained so few borers that it was nearly impossible to find enough forms to depict trends in the second generation (Table 2). However, infestations were heavy in irrigated corn on the Agronomy Farm and in one planting of late non-irrigated corn at the Thomas Farm, 3 miles east of Stillwater where more rain fell than at Stillwater.

Third Generation: Apparently a third generation of D. grandiosella occurred in this area in the fall of 1954, for first instar larvae were found August 26 (Table 2) in the late planted corn at the Thomas Farm and second instar larvae were found September 11 in the irrigated corn at the Agronomy Farm.

Overwintering brood 1954-55: A few immaculate larvae, referred to in the literature as winter form or hibernating larvae, were found as early as mid-July, but the transformation from spotted to immaculate form was not observed in most fields (Table 2) until early September. Because of the disastrous effect of the 1954 drought on corn it is believed that a very low population of borers overwintered in this vicinity in 1954-55. During April and May, 1955, surveys in this area showed that little corn stubble from the 1954 crop was left standing in fields and it contained so few overwintered borers that it was impossible to obtain adequate records on the spring pupation of overwintered larvae and on moth emergence.

Oviposition sites

It has been reported that the lower one-half of the corn plant is the primary site of oviposition for D. grandiosella moths (Davis, et al., 1933). Data taken in this study show that during second generation oviposition 1953 (Table 3) 75.5 per cent of the eggs were found from internode seven to ground level and that in 1954, (Tables 4 and 5) 95.6 per cent of first generation and 98.1 per cent of second generation eggs were found from internode seven to ground level. Also 82.3 per cent of the second generation eggs found in 1953 were on leaf surfaces but in 1954 only 53.2 per cent of first generation and 42.5 per cent of second generation eggs were found on leaves. The rest of the eggs recorded in both years were found on the leaf sheath and stalk surfaces composing the plant internodes.

Larval development and mortality

The high temperatures occurring daily during July apparently had little effect on the percentage of second generation egg hatching (Table 7) but damage to corn by drought apparently produced high mortality among developing larvae (Table 9). A total of 1085 eggs were observed to have hatched on 180 plants during the period June 30-July 23, (Table 7). The plants were dissected during the period July 14-September 2 and only 43 living and 37 dead D. grandiosella forms were found. All of the dead forms were first to fourth instars with the exception of one pupa. Most of the mortality occurred during the period July 14-29. While the number of forms involved (81) (Table 9) is too small to form any definite conclusions, it appears that if developing larvae had access to enough moisture and food to complete the fourth instar, they (in most cases) completed development and pupated. It was observed that fourth, fifth, and sixth instar larvae found in a few plants (Table 9) had apparently made extensive tunnels up and down the stalks completely riddling them before the stalks lodged. All of these larvae were found in the crowns of plants that still contained some moisture, but no girdling of stalks was observed.

In order to show the stage of development of borers in relation to the size of plants in which they were found, drawings (Figure 3, 4, and 5) show corn plants in three growth stages and the number of forms found in each stage.

In Figure 3 the whorl stage of plant growth that occurred in the early planting from June 1 to June 16 is shown. Eighty-eight larvae, ranging in size from first to third instar, were found. They were all located in the plant whorls and were injuring the immature leaves above the plant buds.

The stage of plant growth that occurred in the period June 16-30, when the plants were in the post whorl stage, just prior to tasseling, is represented in Figure 4. During this stage of plant growth, most of the first and second and some of the third instar larvae were found in the ear shoots. Later instars were entering or had tunneled into the stalks. Seven pupa were found in tunnels in internodes two to seven. Only first generation forms were found and none were located in plant crowns.

The tasseling to maturity stage of plant growth is represented in Figure 5. This growth occurred from June 30 to August 4. During this period the plants were severely damaged by drought. It is apparent that both first and second generation larvae were in the plants (Table 2) but it is believed that few second generation forms survived because of the drought injury and that most of those found were first generation forms that had completed their development prior to July 15. Pupae and pupal cases were the most numerous forms found and they were located in the stalks from nodes 13 to the crowns, with more than half found below internode six. An immaculate larva (Figure 5) was found in the crown of a severely drought-injured plant on July 13. It appeared to be of the sixth instar and typical in all respects of the hibernating winter form larvae described by Davis, et al., (1933). Crowns of approximately 150 plants located in the immediate vicinity of the point where this immaculate larva was found were dissected during the period July 14-28 and 14 spotted and seven immaculate larvae were found. These were isolated in shell vials with the material on which they were found. Six of the spotted larvae pupated, five spotted and one immaculate died and three spotted and six immaculate larvae survived to August 15 when they were killed and preserved in alcohol.

Data relating to the number of forms found in plants, that had contained known numbers of hatched eggs, and were dissected on several different dates after the eggs hatched are presented in Table 8. Observations of plants for eggs were made at 3-4 day intervals and the exact dates of hatching were not determined so these data are presented as average time intervals between hatching and plant dissections. Plant records with the same time interval between egg hatching and dissections were found on several dates throughout the growing season. Therefore, the number of eggs hatched and the corresponding time intervals represent data accumulated from several plants taken on several dates during the study. It is believed that the time intervals between hatching and stage of development of larvae found during dissections is accurately represented, for plant records were discarded in all cases where the stage of larval development appeared abnormal for the interval.

The percentages of survival of all forms (Table 8) are recorded for each average time interval between hatching and plant dissections. These data indicated that approximately two-thirds of the larvae failed to survive through the first instar and that little mortality occurred in the last five instars or in the pupal stage. Data in this table indicate considerable variation of development within each stage. First instar larvae were found from 3 to 7 days after hatch; second instar, 3 to 11 days; third instar, 6 to 17 days; fourth instar 13 to 24 days; fifth instar, 19 to 24 days; sixth instar, 20 to 30 days; and pupae 20 to 36 days.

Differentiation of species of *Diatraea*

Larvae: During this study three series of larvae, each composed of approximately 100 forms and including all instars, were studied for possible external characters upon which to base a key to *D. crambidoides*, *D. saccharalis* and *D. grandiosella*. One of these series was collected on sugar cane at Houma, Louisiana and was assumed to be *D. saccharalis* solely on the basis of geographical distribution. The other two series, one collected on corn at Florence, South Carolina and one on corn locally, were assumed, on the same basis, to be larvae of *D. crambidoides* and *D. grandiosella*, respectively. No single character or group of characters was found that would definitely separate one species from another. However, it appears that there may be a difference between shape and also pigmentation of the hypostomal lobes of the post-genae which are approximately medial between the cervex and the base of the labium. The three series of larvae examined were cleared and preserved in a variety of solutions and it is believed that no definite conclusions as to the usefulness of the hypostomal lobes for separating these species can be made until series of larvae are examined that have been collected and preserved under uniform conditions.

Adults: Dyar and Heinrich, (1927) described the front (sic) of *D. grandiosella* as rounded and without a tubercle. Box (1931) reported that, among the specimens of *D. grandiosella* that he examined, all had frons that were rounded and slightly bulging but that a definite rounded protuberance at the apex was present in many. In examining a series of 65 *D. grandiosella* moths in the collection at Oklahoma A. & M. College, it was found that 46 specimens, including both sexes, had rounded frons with slight to distinct protuberances at the apex while 19 specimens, including both sexes possessed rounded frons with no protuberances.

Box (1931) in discussing *D. saccharalis* (page 24) states "It should be noted, however, and taken as a guide to identification, that among the 426 specimens examined by the writer in the course of the present studies the shape of the frons is constant, being convex, somewhat bulging and without any tendency to be produced into a point at the apex. Nevertheless, the genitalia are the only sure criterion for a diagnosis and their examination should be resorted to whenever there is an element of doubt." During this study seven specimens of *D. saccharalis*, collected at Monterey, Mexico and identified by S. Capps of the National Museum, Washington D. C., were examined. Three of the seven possessed a frons with a protuberance at the apex similar to those found in *D. grandiosella*.

CHAPTER V

DISCUSSION

Most of the moths from the overwintering brood of D. grandiosella in this area emerged in May (Table 1) in 1954. Walton and Bieberdorf (1948) reported most emergence of spring moths occurred in June in this area. This suggests as Davis, et al., (1933) have shown, that spring emergence varies from year to year because of variation in weather conditions. Mortality of overwintering larvae is reported (Davis, et al., 1933) as much higher during extremely cold winters and that many larvae surviving such conditions are so weak that they are unable to pupate in the spring. Locally, the winter of 1953-54 was considered mild and few dead larvae or pupa were noted when emergence data were taken in April and May.

The variation of development of D. grandiosella from field to field is reported by Davis, et al., (1933). During this study it was found that seasonal history records taken from different fields in the same area at the Agronomy Farm (Table 2) indicated slight differences in borer development between fields and that extreme differences were found between fields that were irrigated and those that were not.

The period of incubation, five to six days, is not always the same for eggs in individual masses (Davis, et al., 1933) for a few found here contained eggs that hatched on different dates. Also, infertile and fertile eggs were observed in the same mass in a few cases.

A comparison of the differences in location of egg masses found during the second generations of 1953 and 1954 is presented in Table 11. Data taken in 1953 indicated that more eggs are deposited on leaves than sheath and stalk surfaces. Davis, et al., (1933) and Wilbur, et al., (1950) indicated that leaves are the primary sites of oviposition, however, data taken in 1954 on plants suffering from drought damage show that more eggs were deposited on stalk surfaces and that moths deposited eggs lower on the plants than in 1953. It is believed that second generation eggs were deposited lower on the plants in 1954 because of drought, i. e., that as the corn was damaged by drought the higher parts of the stalk and leaves turned brown first, causing moths to deposit eggs lower on the still green portions of the corn plants. Indications are that D. grandiosella moths prefer green plant surfaces for oviposition, but that this preference is related to plant condition rather than specific parts of the plants.

Apparently, the location of larvae of D. grandiosella within plants depends on their stage of development and the type of plant tissue required by them. First, second and most of the third instar larvae found during the whorl stage of growth (Figure 3) were in the moist tender immature leaves and enclosed tassels of the whorls. As whorls opened on plants and these tissues became tougher and less moist, early instar larvae were usually found within the tender ear shoots at internodes lower on the plant. This indicates that early instar larvae prefer any above ground parts of corn plants that are tender and moist. It is believed that the low survival of second generation larvae in 1954 was the result of a lack of moisture since they were invariably found in the tender ear shoots that are normally moist but in this case had dried because of drought. Most of the larvae entered the stalks while in the third and fourth instar and apparently preferred to tunnel the lower half of stalks (Figure 4). It was not uncommon for a borer to enter a stalk and tunnel several inches and then emerge and reenter the stalk at a different location (usually lower) to pupate. Pupation was found to occur usually in tunnels in stalks or in crowns, however, a few pupae were found in ear shanks, brace roots and in furled leaves of "dead-hearted" plants. It is believed that pupation takes place at the bottom of tunnels and that pupal cases found protruding from tunnel exit holes are left there as a result of emerging moths failing to disengage them prior to reaching the exit holes. Wilbur, et al., (1950) in Kansas indicated that only immaculate larvae girdle plants. It has been observed here that many plants are girdled by spotted borers prior to transformation to the immaculate form. They (Wilbur, et al., 1950) state that injury to ears by D. grandiosella larvae was not found in sweet corn in Kansas. A field of sweet corn observed at Stillwater in 1954 had approximately 20 per cent of the ears tunneled at the base with appreciable injury to kernels.

Drought-damage to corn apparently causes high mortality of larvae in corn plants (Table 9) and also causes abnormal behavior. During the second generation (1954) dry corn stalks had been riddled by extensive tunneling and the few surviving late instar borers were found in the crowns of plants.

The finding of immaculate larvae within crowns of drought damaged plants as early as mid-July is considered an indication that the phenomenon of hibernation of D. grandiosella and possibly D. crambidoides should be investigated more thoroughly. Davis, et al., (1933) stated "with the intervention of cooler fall weather a large majority of the full grown larvae and some not quite full grown leave their feeding places higher up in the stalk and move to its base, entering either by tunneling down the stalk, by gnawing in through sound tissue; or, more rarely, through the exit hole of a borer of the previous generation. Upon reaching the extreme base of the stalk they hibernate." Hibernation of D. grandiosella is also reported by Walton and Bieberdorf (1948) and Wilbur, et al., (1950). Considering that the genus Diatraea typically is of tropical or subtropical origin it is believed that the period of dormancy occurring among D. grandiosella should not be entirely associated with the onset of cool fall weather. Indications are that this phenomenon may be merely an advantageous adaptation enabling the species to survive during periods of adverse conditions. Kevan (1943) and Painter (1955) report that D. lineolata has a resting stage in dry or mature corn between rainy seasons in Guatemala.

It was found here that immaculate borers taken from dry corn plants did not all appear to be of the sixth instar, the size Davis, et al., (1933) reports for immaculate larvae. Drought had so damaged the corn crop that apparently little food or moisture was available for larval development. Temperatures (Table 12) were exceedingly high prior to the finding of immaculate larvae in mid-July. Under the conditions of this study an explanation of what caused these larvae to enter a resting stage, normally associated with cooler fall temperatures, cannot be given. However, there is some justification in contending that this phenomenon in addition to being an adaptation for overwintering, also may be an adaptation for survival during periods of extremely high temperature, moisture or food deficiency, or other adverse conditions not delineated in this study.

Under the conditions encountered during this study, significant differences in resistance of corn to the southwestern corn borer were not found (Table 11). Under ideal weather conditions during 1953, more second generation egg deposition occurred on the resistant cross (OK12x-CI7) but under conditions of drought during 1954 the susceptible cross (K4xK201) received more eggs. In both years 100 per cent of the plants received eggs.

The percentages of eggs hatched (Table 11) were approximately the same during the first generation, but differed between the two crosses by about 6 per cent in the second generation. This difference is largely attributable to parasitization by *Trichogramma minutum* Riley. Data in Table 7 show that 24 per cent of the second generation eggs found on OK12xCI7 were parasitized while only 12.5 per cent were parasitized on K4xK201.

A difference in survival of first generation forms (Table 11) (46.4 per cent for OK12xCI7; 61.9 for K4xK201) was indicated. It is believed that these data are not reliable because of inadequate sampling methods.

They are based on the total number of eggs hatched and the total number of forms found for each cross during the first generation. It was found during plant dissections that approximately 10 per cent of the plants had been recorded as not receiving eggs and yet contained larvae. However, an attempt was made to always give equal observational treatment to the two crosses and it is believed that the data, while an inaccurate estimate of larval survival are indicative of the ability of larvae to survive better in the susceptible cross, K4xK201.

Indications are that the total survival percentage (32.9) presented in Table 8 more accurately estimates larval survival. Data in this table include only those plants of both crosses on which specific numbers of eggs were known to have hatched and in which the larvae hatched therefrom were believed to show a stage of development that appeared normal for the time period after hatching. However, it is admitted that these data are based solely on selection and therefore dependent on the skill and experience of the investigator.

It is believed that studies of resistance of corn to the southwestern corn borer should be made on plants subjected to the best cultural and weather conditions possible. In this study it was evident (mid-July to September, 1954) (Tables 9, 11, 12) that regardless of any difference in resistance between the two crosses of corn, drought injury to plants was the major cause of the low infestation, and that the number of borers found in each cross was so low that comparisons of the crosses were valueless. It is believed that in this area of

Oklahoma, if studies of corn resistance to southwestern borer are to be made, irrigation should be available to minimize the possibility of crop failure when weather is unfavorable.

The data (Table 11) indicate that first generation egg deposition was distributed rather uniformly between the two crosses when considered on an individual plant basis. Eighty-seven of 150 resistant (OK12xCI7) plants received 372 eggs and 70 succeptible (K4xK201) plants received 301 eggs. This is, for each cross, approximately 4.3 eggs per plant that received eggs. Prior to this study it was debatable whether or not enough first generation egg deposition would occur, and would it be distributed uniformly enough between crosses to make comparison feasible. Apparently the planting of the crosses in adjacent blocks and the selection of enough plants for study throughout the field (150 each cross) minimized the effect of spotty infestation of southwestern corn borer known to occur in this area.

CHAPTER VI

SUMMARY

A study of the oviposition and larval habits of the southwestern corn borer was made in the vicinity of Stillwater, Oklahoma from June to September, 1954. Two single crosses of corn that, on the basis of past tests, had shown some difference in degree of infestation were compared for the number of southwestern corn borer eggs and the number of developing larvae present on or in each throughout the growing season.

Results indicated that eggs were found lower on corn plants in 1954 than previous years and that apparently this was caused by drought damage to plants. Leaves of the lower half of corn plants, considered by some authors to be the primary site of oviposition of D. grandiosella moths, received fewer eggs than did the stalk and internodes of plants. Indications are that ovipositing moths show a preference for green plant tissue but not for specific parts of plants.

Early instar larvae were usually found in the tender moist tissue of whorls of young plants and ear shoots of more mature plants. They moved from these sites and began tunneling into stalks while in the third or fourth instar. Survival of first generation larvae was estimated at 32.9 per cent. Survival of second generation forms was much lower (approximately 4 per cent), apparently as a result of high mortality among early instar larvae caused by drought-damage to plants. The transformation of larvae from spotted to immaculate stage, noted during this study in early July, indicates that the immaculate larval stage should not be associated entirely with the onset of cooler fall temperatures and hibernation.

Under the conditions existing during this study, significant differences in resistance of corn to the southwestern corn borer were not observed between the crosses OK12xCI7 and K4xK201, described as resistant and susceptible, respectively, in earlier studies.

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TABLE 1

Pupation and emergence of the 1953-54 overwintering brood of *Diatraea grandiosella* Dyar, Paradise, Oklahoma.

Date	Number of forms	Per cent pupation	Per cent Moth emergence
April 26	51	39.2	
May 3	25	52.0	
May 4	50	86.0	
May 10	50	90.0	8.0
May 17	50	100.0	22.0
May 27	40	100.0	87.5

TABLE 2

Stage of development of <u>Diatraea grandiosella</u> Dyar, taken in corn fields in the Stillwater Area, Payne County, Oklahoma, 1954.

Date	Field location	Total forms	Per cent of total forms found I	II	III	IV	V	VI	Pupa	Pupal cases
June 1	Agron. Farm	101	30.7	61.4	7.9					
6	Agron. Farm	102	39.2	31.4	29.4					
11	Agron. Farm	89	40.4	42.7	16.9					
16	Agron. Farm	106	17.9	38.7	26.4	9.4	3.8	3.8		
20	Agron. Farm	101	11.9	22.8	31.6	20.8	11.9	1.0		
23	Agron. Farm	101		5.9	19.8	15.8	26.7	18.8	11.9	
28	Agron. Farm	100			8.0	17.0	34.0	27.0	14.0	
29	Paradise	101			1.0	2.0	12.9	29.7	54.4	
July 2	Agron. Farm	105	3.8			4.8	13.3	22.8	43.8	11.5
2	Paradise	104					1.9	15.4	68.3	14.4
5	Paradise	102	2.0	1.0	2.9		4.9	11.8	54.9	22.5
7	Agron. Farm	100	9.0	6.0	4.0	3.0	1.0	3.0	22.0	52.0
15	Agron. Farm	65	10.8	6.1	13.8	18.5	9.2	3.1	4.6	33.9
27	Agron. Farm	59		6.8	11.9	8.5	28.8	13.5	20.3	10.2
Aug. 3	Agron. Farm	80		2.5	12.5	7.5	16.2	31.3	13.7	16.3
10	Agron. Farm	77		2.6	1.3	7.8	3.9	5.2	19.5	59.7
17	Agron. Farm	75				5.3	8.0	5.3	20.0	61.4
Late planted non-irrigated corn										
19	Thomas Farm	111	2.7	9.9	14.4	7.2	20.7	16.2	4.5	24.3
26	Thomas Farm	100	5.0	9.0	8.0	7.0	14.0	22.0		35.0
Irrigated corn										
Aug.13	Agron. Farm	100			10.0	7.0	10.0	7.0	32.0	34.0
24	Agron. Farm	63					4.8	6.3	3.2	85.7
26										
Sept.8	Agron. Farm	107					3.7	*7.5	4.7	84.1
11	Agron. Farm	118		2.7	6.8	16.1	11.0**	36.4	7.6	19.4

* 1 of 8 winter form
** 9 of 43 winter form

TABLE 3

Location of Diatraea grandiosella Dyar eggs on corn plants, second generation, July 10-25, 1953. Agronomy Farm, Stillwater, Oklahoma.

*Inter-node	Leaf surface Upper	Lower	**Sheath and stalk	Total eggs each internode	Per cent of total
14		3		3	.1
13	5	3		8	.4
12	15	18	2	35	1.7
11	12	34		46	2.3
10	40	46	10	96	4.8
9	94	32	9	135	6.7
8	88	66	17	171	8.5
7	97	70	19	186	9.2
6	133	64	36	233	11.5
5	175	97	83	355	17.6
4	171	94	92	357	17.7
3	65	77	51	193	9.6
2	40	59	22	121	6.0
1	36	27	16	79	3.9
Total	971	690	357	2018	
Per cent of total	48.1	34.2	17.7		

* Internodes counted from first above ground upward.

** Sheath and stalk - designated as the areas of the corn plant between two nodes

TABLE 4

Location of <u>Diatraea grandiosella</u> Dyar eggs on corn plants, first generation, May 20-June 23, 1954. Agronomy Farm, Stillwater, Oklahoma.

Inter-node	Leaf surface Upper	Leaf surface Lower	**Sheath and stalk	Total eggs each internode	Per cent of total
10	3			3	0.4
9	6			6	0.9
8	12	9		21	3.1
7	22	4		26	3.9
6	36	13		49	7.3
5	36	2	29	67	10.0
4	53	20	32	105	15.6
3	62	33	68	163	24.2
2	25	13	85	123	18.3
1	9		64	73	10.8
*			37	37	5.5
Total	264	94	315	673	
Per cent of total	39.2	14.0	46.8		

* Internode 1 to ground level

** Sheath and stalk - designated as the areas of the corn plant between two nodes.

TABLE 5

Location of Diatraea grandiosella Dyar eggs on corn plants, second generation, June 30-July 22, 1954. Agronomy Farm, Stillwater, Oklahoma.

Inter-node	Leaf surface Upper	Leaf surface Lower	**Sheath and stalk	Total eggs each internode	Per cent of total
12		2		2	.1
11	7			7	.4
10	2			2	.1
9	11	2		13	.8
8	6	2		8	.5
7	30	9		39	2.4
6	48	10	1	59	3.7
5	50	12	6	68	4.3
4	88	21	101	210	13.2
3	132	28	304	464	29.0
2	140	26	372	538	33.6
1	37	17	121	175	10.9
*			15	15	1.0
Total	551	129	920	1600	
Per cent of total	34.5	8.0	57.5		

* Internode 1 to ground level

** Sheath and stalk - designated as the areas of the corn plant between two nodes

TABLE 6

Fate of first generation Diatraea grandiosella Dyar eggs found on 300 corn plants, May 20-June 23, 1954. Agronomy Farm, Stillwater, Oklahoma.

	Single crosses				Both crosses	
	OK12xCI7		K4xK201			
	No.	Per cent	No.	Per cent	No.	Per cent
Masses	116		84		200	
Eggs	372		301		673	
Parasitized	7	1.8	5	1.7	12	1.8
Lost	17	4.6	19	6.3	36	5.4
Infertile	9	2.4	6	2.0	15	2.2
Eaten	3	.8			3	.4
Hatched	336	90.4	271	90.0	607	90.2

TABLE 7

Fate of second generation <u>Diatraea grandiosella</u> Dyar eggs found on 180 corn plants, June 30-July 23, 1954. Agronomy Farm, Stillwater, Oklahoma.

	Single crosses				Both crosses	
	OK12xCI7		K4xK201			
	No.	Per cent	No.	Per cent	No.	Per cent
Masses	373		380		753	
Eggs	782		818		1600	
Parasitized	188	24.0	104	12.5	292	18.3
Lost	46	5.9	70	8.5	116	7.3
Infertile	31	4.0	43	5.3	74	4.6
Eaten	10	1.3	23	2.8	33	2.0
Hatched	507	64.8	578	70.7	1085	67.8

TABLE 8

Number of first generation <u>Diatraea</u> <u>grandiosella</u> Dyar found in corn plants, May 28–July 1, 1954. Agronomy Farm, Stillwater, Oklahoma.

No. of hatched eggs	*Average time interval hatching to plant dissection in days	Number of forms	Stage of development							Per cent survival
			I	II	III	IV	V	VI	Pupa	
25	3	9	8	1						36.
39	4	22	14	8						56.4
15	5	5	2	3						33.3
25	6	11	2	8	1					44.0
45	7	14	6	8						31.1
50	10	16		3	13					32.0
31	11	8		6	2					25.8
27	13	7			2	5				25.9
11	14	4			4					36.4
22	17	8			3	5				36.4
4	19	1					1			25.0
8	20	5					2	2	1	62.5
12	22	4						3	1	33.3
26	24	13				2	3	2	6	50.0
10	25	3							3	30.0
3	27	2							2	66.7
6	28	3							3	50.0
13	29	5							3	38.5
18	30	4						2	3	22.2
29	32	6						1	6	20.7
21	34	4							4	19.0
41	36	11							11	26.8
Total 501		165	32	37	25	12	6	10	43	32.9

* Data taken at 3 to 4 day intervals.

TABLE 9

Number and stage of development of *Diatraea grandiosella* Dyar from July 14–September 2, 1954, found in 180 plants on which 1600 second generation eggs had been deposited. Agronomy Farm, Stillwater, Oklahoma.

*Date of Dissection	Number of forms		Stage of Development I	II	III	IV	V	VI	Pupae
July 14	36	Living	10	3	1				
		Dead	16	6					
July 20	20	Living	4	2	3				
		Dead	3	3	5				
July 23	8	Living	2	1		1			
		Dead	1		2	1			
July 29	4	Living			1		2		
		Dead			1				
Aug 4	1	Living						1	
		Dead							
Aug 11	5	Living						2	3
		Dead							
Aug 17	3	Living							2
		Dead							1
Aug 24	2	Living						1	1
		Dead							
Sept 2	2	Living							2
		Dead							
Total	81	Living	16	6	5	1	2	4	8
		Dead	20	9	8	1			1

* 20 plants were dissected each date.

TABLE 10

Comparison of differences in location of eggs of *Diatraea grandiosella* Dyar during the second generations of 1953 and 1954. Stillwater Area, Payne County, Oklahoma.

	July 10-25, 1953	June 30-July 22, 1954
Percentage found on leaf surfaces	82.3	42.5
Percentage found on leaf sheaths and stalks	17.7	57.5
Percentage found on leaves, sheaths and stalks from node 6 to ground	66.3	91.7
Percentage found on leaves, sheaths and stalks from node 6 to tassel	33.6	8.3
Total eggs found	2018	1600

TABLE 11

Comparison of differences in infestation of <u>Diatraea grandiosella</u> Dyar on two single crosses of corn, 1953-54. Agronomy Farm, Stillwater, Oklahoma.

	Resistant OK12xCI7	Susceptible K4xK201
Second generation 1953		
Number of eggs July 10-25	1136	882
First generation 1954		
Number of eggs May 20-June 23	372	301
Per cent hatched	90	90.4
Per cent of plants receiving eggs	58.0	46.6
Number of larvae in plants	156	168
Per cent of plants infested	43.7	51.3
Per cent survival	46.4	61.9
Second generation 1954		
Number of eggs June 30-July 23	782	818
Per cent hatched	64.8	70.7
Per cent of plants receiving eggs	100	100
Number of larvae in plants	24	19
Per cent plants infested	17.7	13.3
Per cent survival	4.7	3.3

TABLE 12

Temperatures in degrees Fahrenheit and precipitation, April 1- September 30, 1954, Stillwater, Oklahoma.

April				May				June			
Day	Max.	Min.	Inches	Day	Max.	Min.	Inches	Day	Max.	Min.	Inches
1	63	23		1	69	49	0.18	1	80	52	
2	75	43		2	55	42	2.01	2	79	58	0.12
3	84	46		3	55	33		3	71	51	
4	88	48		4	64	36		4	78	46	
5	84	59		5	75	44		5	84	52	
6	95	65		6	80	53		6	87	65	
7	75	61		7	76	49	0.42	7	83	68	T
8	72	44		8	68	50	0.03	8	90	66	
9	77	50		9	62	52	0.11	9	91	65	0.17
10	83	59		10	58	47	0.14	10	91	70	
11	67	56		11	59	49		11	93	72	
12	60	54	0.06	12	71	52	0.03	12	92	72	1.60
13	68	48	0.12	13	77	52		13	91	62	
14	79	58		14	78	50		14	91	71	
15	74	60	0.32	15	81	54		15	83	62	0.48
16	67	43		16	80	59		16	90	62	
17	87	45		17	66	56	0.01	17	94	68	
18	89	54		18	79	52	0.07	18	94	72	
19	85	60		19	76	56		19	94	73	
20	85	63		20	69	50	T	20	92	74	
21	77	65		21	80	56		21	94	72	
22	62	52	0.25	22	87	60		22	99	73	
23	84	58	0.03	23	84	68		23	100	72	
24	88	59		24	81	60	1.01	24	98	72	
25	89	62		25	73	58	0.46	25	98	74	
26	86	63	0.30	26	80	61	0.22	26	96	73	
27	77	59		27	85	64		27	96	71	
28	76	60	T	28	80	69		28	97	70	
29	86	61		29	81	68		29	98	68	
30	60	57	1.16	30	88	60	0.48	30	98	71	0.12
				31	85	63	0.24				
Total monthly precipitation			2.24				5.41				2.49

TABLE 12 (continued)

Temperatures in degrees Fahrenheit and precipitation, April 1-September 30, 1954, Stillwater, Oklahoma.

July				August				September			
Day	Max.	Min.	Inches	Day	Max.	Min.	Inches	Day	Max.	Min.	Inches
1	99	71		1	96	72		1	100	66	0.05
2	102	74		2	97	66	0.97	2	103	67	T
3	101	73		3	103	67		3	105	71	0.29
4	101	74		4	102	76		4	101	73	
5	101	71		5	102	80		5	99	65	
6	104	75		6	100	80	T	6	101	68	
7	106	77		7	103	75	0.27	7	93	71	
8	101	71	T	8	82	70		8	97	63	
9	104	74		9	94	63		9	89	64	
10	106	76		10	103	65		10	83	59	
11	101	77		11	105	69		11	86	55	
12	111	77		12	103	82		12	93	55	
13	112	76		13	102	72		13	97	60	
14	113	80		14	105	75		14	94	61	
15	105	81		15	105	78		15	100	64	
16	109	76		16	106	81		16	100	65	
17	109	79		17	105	81		17	95	65	
18	111	82		18	103	79		18	99	69	
19	108	82		19	103	81		19	102	69	
20	107	75		20	98	72	T	20	102	80	
21	104	77		21	100	72		21	80	58	
22	108	83		22	99	80		22	84	46	
23	107	78		23	97	74	0.63	23	85	50	
24	103	75		24	97	71		24	90	54	
25	105	78		25	100	72		25	89	56	
26	98	79	0.03	26	103	74		26	91	62	
27	100	71		27	105	75		27	94	67	T
28	99	73		28	104	75		28	94	70	0.60
29	102	75		29	106	72	T	29	93	73	0.02
30	97	73		30	105	72	0.06	30	75	66	T
31	95	75		31	96	69					
Total monthly precipitation			0.03				1.93				0.96

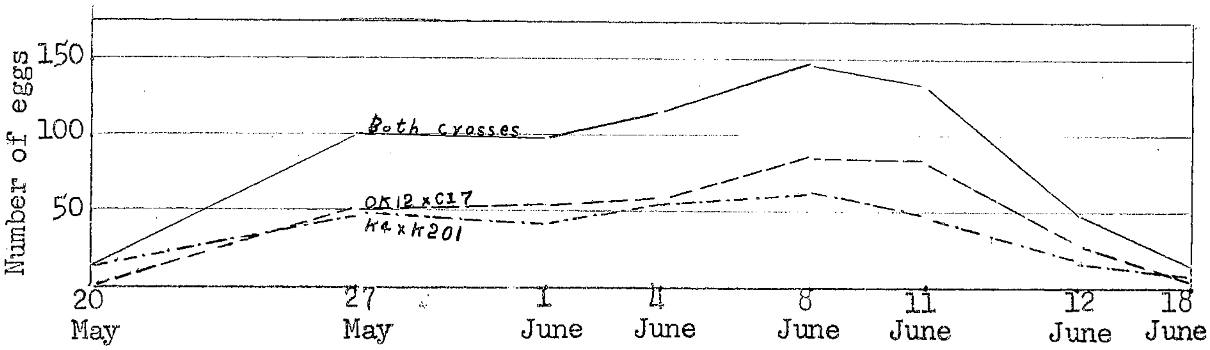


Figure 1. First generation oviposition of Diatraea grandiosella Dyar on two single crosses of corn, 1954. Agronomy Farm, Stillwater, Oklahoma.

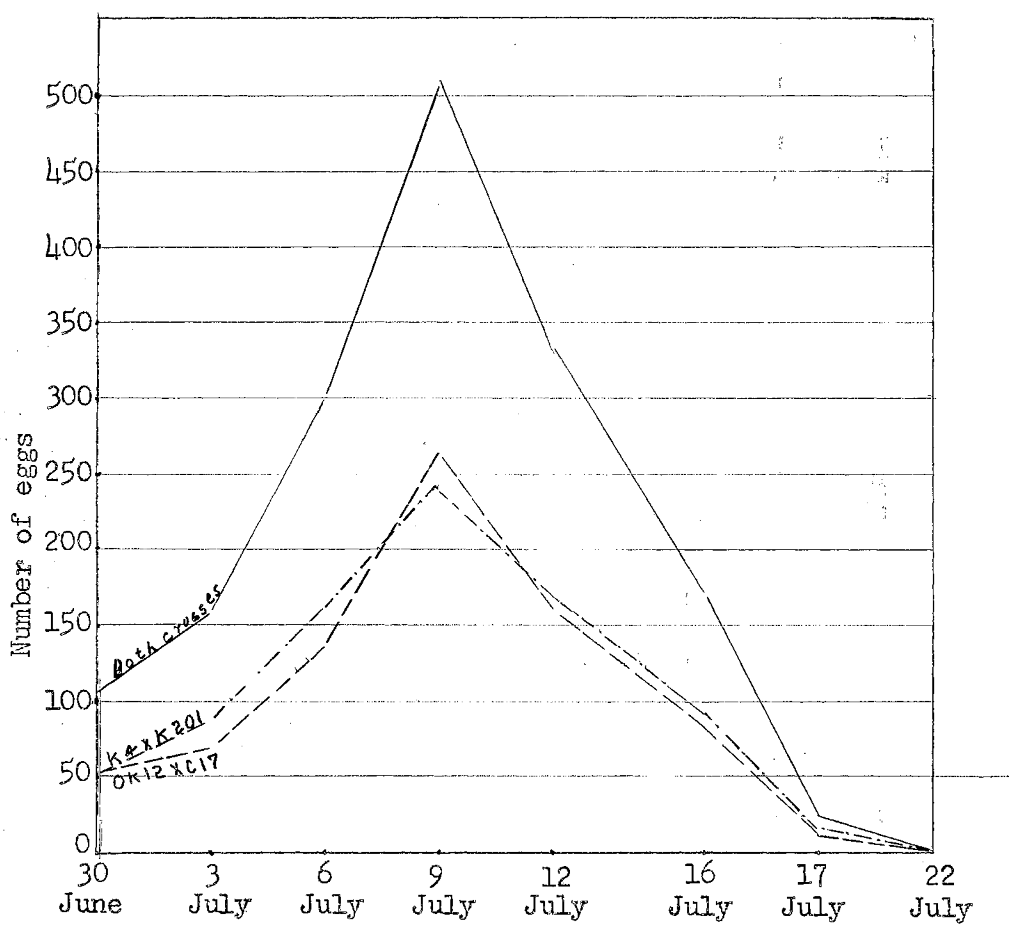


Figure 2. Second generation oviposition of Diatraea grandiosella Dyar on two single crosses of corn, 1954. Agronomy Farm, Stillwater, Oklahoma.

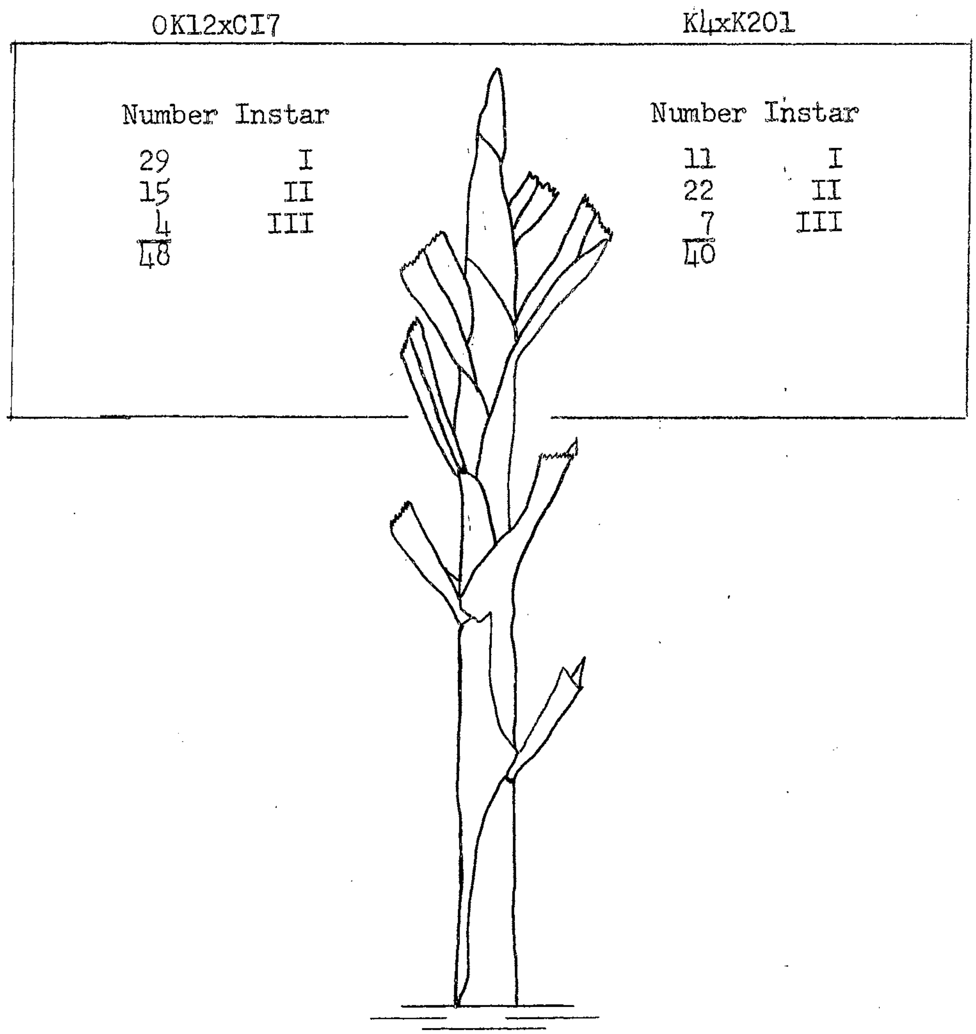
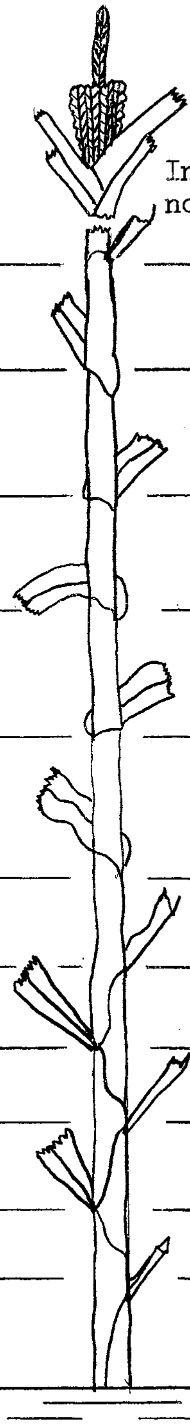


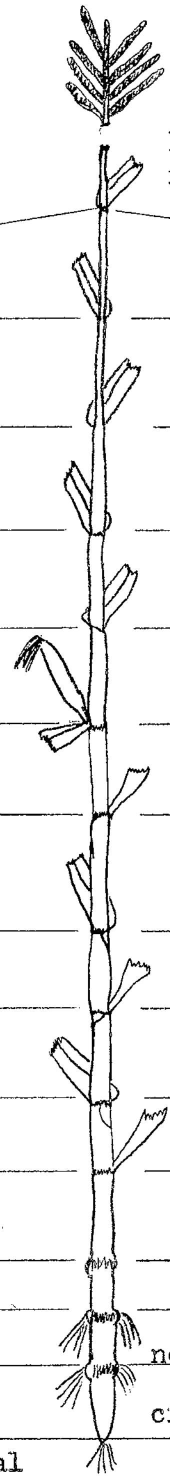
Figure 3. Location and stage of development of first generation *Diatraea grandiosella* Dyar in corn plants in the whorl stage of growth, 1954. Agronomy Farm, Stillwater, Oklahoma.



OK12xCI7 Loc. & stage of dev. I	II	III	IV	V	VI	P**	Internode No.	K4xK201 Loc. & stage of dev. I	II	III	IV	V	VI	P**
				1			11			3				
							10		*2					
*1			1		1		9	1						
			2				8			1	2		1	1
	*1		1	1	1	1	7		1	*1 2	1	1		
		1				1	6	*1		1			2	
	*2						5		*1		1	1		
*1	1	2	1	1			4							2
*1		1	2	1	1		3			2	2	1		1
			1			1	2		*1				2	
							1							
3	4	4	8	4	3	3		2	5	10	6	3	5	4

* Found in ear shoots ** Pupae

Figure 4. Location and stage of development of first generation _Diatraea grandiosella_ Dyar in corn plants, post _whorl to tassel stage_ of growth, 1954. Agronomy Farm, Stillwater, Oklahoma.



OK12xCI7 Loc. & stage of dev. I	II	III	IV	V	VI	P**	Internode No.	K4xK201 Loc. & stage of dev. I	II	III	IV	V	VI	P**
							12							1
							11							2
						3	10							5
						8	9							4
	*1					7	8		*1	1				5
	*1					5	7						1	4
						4	6	*1	*1	1				6
			1			10	5					1		8
*1			1			7	4		2					15
						6	3				1			5
						9	2							10
						2	1							3
							node 1 to ground level							1
					2	12	crown						***3	11
1	2		2		2	73	total	1	4	2	1	1	6	80

* found in ear shoot ** Pupae *** 1 of 3 immaculate

Figure 5. Location and stage of development of first and second generation Diatraea grandiosella Dyar in mature corn plants, 1954. Agronomy Farm, Stillwater, Oklahoma.

VITA

Sess D. Hensley
candidate for the degree of
Master of Science

Thesis: THE OVIPOSITION AND LARVAL HABITS OF *Diatraea grandiosella* Dyar IN OKLAHOMA

Major: Entomology

Biographical and Other Items:

Born: January 18, 1920 at Smithville, Oklahoma

Undergraduate Study: Southern State College, 1946-47, O.A.M.C., 1952-54.

Graduate Study: O.A.M.C., 1954-55.

Experiences: Farming, 1934-40; United States Army, Radio Operator, Qualified Parachutist, Alaskan Defense Command, European Theatre of Operations WW/II, 1941-45; Administrative Assistant, National Guard Bureau, 1948-50; 1 st./Sgt., Korean Campaign, 1950-52; Research Assistant, Entomology O.A.M.C. Summers; 1952-53; Field Aid, GS-3, (Irregular), Div. of Cereal and Forage Insect Investigations, Entomology Research Branch, Agri. Research Service, U.S.D.A.

Member of Sigma Xi, Alpha Zeta, Phi Sigma, Entomological Society of America and the Sanborn Entomology Club.

Date of Final Examination: July, 1955.

THESIS TITLE: THE OVIPOSITION AND LARVAL HABITS OF *Diatraea grandiosella* Dyar IN OKLAHOMA

AUTHOR: Sess D. Hensley

THESIS ADVISER: Dr. D. E. Howell

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TYPIST: Sara Preston