# THE HABITS AND LIFE HISTORY OF A PYRALID MOTH, *SURATTHA INDENTELLA* KEARFOTT, ATTACKING BUFFALOGRASS IN KANSAS. (LEPIDOPTERA: PYRALIDAE)

by

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# INTRODUCTION

## Importance

The first reliable record of the presence of Surattha indentella Kearfott in Kansas was obtained in the summer of 1965. Damage to buffalograss fairways was called to the attention of Dr. H. E. Thompson by Walter Ralph, groundskeeper at the Larned Country Club, Pawnee County. Larvae were collected in 1965 and 1966 and sent to the United States Department of Agriculture Identification Section for identification. They were identified as a species of Crambidae by D. M. Weisman. He reported no reared larval material was available for comparison in the U.S.N.M. collection. Other larvae were reared to adulthood and sent to Dr. A. B. Klots of the American Museum of Natural History. They were identified as Surattha indentella Kearfott by Dr. A. B. Klots. Dr. R. W. Hodges of the U. S. Department of Agriculture Identification Section later confirmed this identification. Dr. A. B. Klots (personal communication) stated "that the specimens collected in Kansas were considerably darker than the types, and the possibility exists of a very close species or a darker local population." He further stated "that there is simply not enough material in existence of this genus in North America to enable him to make a definite statement about this species or subspecies."

This insect may have been present in Kansas for many years. Several county extension agricultural agents in south-central Kansas recall similar damage to buffalograss by sod webworms several years ago, but they did not distinguish it from other sod webworms described in extension entomological releases.

Surattha indentella may be considered a sod webworm, for its feeding and behavioral habits, its habitat and subsequent damage are similar to other Lepidoptera with the common name, sod webworm. However, S. indentella is not a member of the genus Crambus which includes many of the other more familiar sod webworms, nor is it a true close wing lawn moth. It must be considered more of a burrowing sod webworm possessing a horizontal surface tube, as well as a vertical tunnel.

Surattha indentella was observed principally on buffalograss fairways and lawns in south-central Kansas. However, it was also found on bentgrass greens and bermudagrass lawns with a previous history of buffalograss. The author has no record of injury caused by S. indentella to cultivated crops, and its destructiveness seems to be limited to areas more or less permanently in sod.

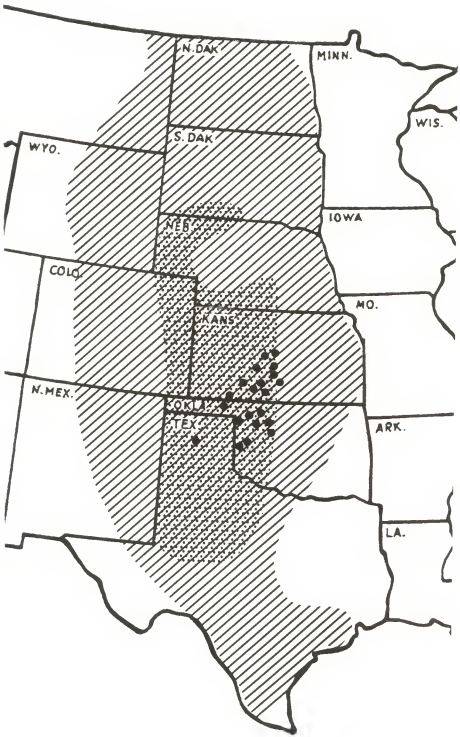
Buffalograss, Buchloe dactyloides (Nutt.) Engelm., is a low growing, long-lived, warm season, drought resistant perennial grass that occurs naturally throughout the Great Plains region from the Canadian border to the Rio Grande river. Wenger (1943) states "that buffalograss is of greatest importance in the Central Plains area where it and blue grama (Bouteloua gracilis Lag.) comprise more than 90 per cent of the native vegetation on the non-sandy soils. This area of major importance embraces approximately 190,000 square miles and includes south-central and the extreme western half of Nebraska, the western half of Kansas, the eastern fourth of Colorado, the western third of Oklahoma and northwest Texas." (Plate I)

## EXPLANATION OF PLATE I

Map showing area of major and minor distribution of buffalograss in the Great Plains.

Solid circles represent locations of Surattha indentella Kearfott infestations. Eleven observed infestations in Kansas, and nine in Oklahoma. The one in Texas represents the original collection in 1902 reported by Kearfott.

PLATE I


N. DAK.
MINN.
WIS.
S. DAK.
WYO.
NEB.
IOWA
COLO.
KANS.
MO.
N. MEX.
OKLA.
TEX.
ARK.
LA.

According to Wenger (1943), buffalograss is one of the important crops of Kansas and of the Central Great Plains states. In addition to being an excellent pasture grass it has many other uses for such purposes as lawn and landscape development, erosion control, airfields, highway development, athletic fields, golf courses, parks, and cemeteries.

The economic importance of S. indentella, though difficult to estimate with any degree of accuracy, is none the less extensive. Such extensive damage as observed during the summer of 1966 to buffalograss turf by S. indentella requires costly replacement or renovation measures, in addition to the use of expensive and somewhat inadequate control methods. With as many as 72 larvae per square foot found damaging buffalograss fairways at the Larned Country Club the summer of 1967, and with each consuming a blade or two of grass daily, this represents a considerable amount of cover removed over the course of a two month larval period.

Damage consists of repeated defoliation of blades of grass through the months of June and July, and, when accompanied by drought, may cause permanent defoliation with eventual death of plant resulting. Following death of the plant, barren areas appear and with the occurrence of rain gradual succession of weeds takes place. Once weeds are established, adjacent areas of buffalograss may in time be eventually crowded out and replaced by them and other undesirable grasses (Plate II).

It was the objective of this thesis to determine the habits and life history of Surattha indentella Kearfott, and the taxonomic relationship, economic importance, and distribution in Kansas.

EXPLANATION OF PLATE II

Damage to a buffalograss fairway by Surattha indentella Kearfott.

Note barren area in foreground and succession of weeds in upper left corner.

PLATE II

## Review of Literature

There is little published information available on S. indentella, other than the original description. Kearfott (1908), preceding his descriptions of several new species of North American Crambid Moths, stated "that little or nothing is known of the life histories," and more recently Dr. A. B. Klots in a personal communication stated "that in the Microlepidoptera Palearctica the genus Surattha is very thoroughly covered but no life histories appear to be known."

## Taxonomic Status

Surattha indentella was first described by W. D. Kearfott on October 31, 1908 from two male specimens collected in Amarillo, Texas on August 30, 1902 by Cockerell (Kearfott, 1908). The cotypes are in the collection in the United States National Museum Cat. No. 11948, and in Kearfott's collection (Kearfott, 1908). According to Dr. A. B. Klots (personal communication), the only known specimens are the types and three additional specimens from College Station, Texas in the United States National Museum. Kearfott based his description on the venation and color of the wings, and the color of the body. In Kearfott's justification statement for establishing a new species, S. indentella, he stated "that the venation and structure of this species agrees exactly with Hampson's, fig. 47, p. 965, Proc. Zool. Soc. Lond., 1895 except that the termen of forewing is slightly indented at veins 4 and 5" (Kearfott, 1908).

The genus Surattha was originally described by Walker (1863). A later description of the genus Calarina by Walker (1866), as was a subsequent description of the genus Platytesia by Strand (1918), proved to be synonymous and were dropped by the rule of priority. Hampson (1895) listed seven species of the genus Surattha in addition to a figure of the generic type, S. invectalis Walker (1863).

Bleszynski (1962) listed 36 species in the genus Surattha. All of them with the exception of S. indentella in Texas and S. santella in Arizona are Old World species.

## MATERIALS AND METHODS

### Study Areas

Field observations were made at several locations in south-central Kansas (Plate III). The Larned Country Club was chosen as the major study area in 1966 because of a heavy infestation. It was also the initial and most accessible infestation. Additional observations and data were made on infestations at the Ellsworth Country Club, and the Alois Demel farm in Barton County. Infestations at other locations were recorded to determine the distribution.

Observations were made on buffalograss and other grasses grown in flats or clay pots artificially infested in the Kansas State University greenhouse and growth chamber.

## EXPLANATION OF PLATE III

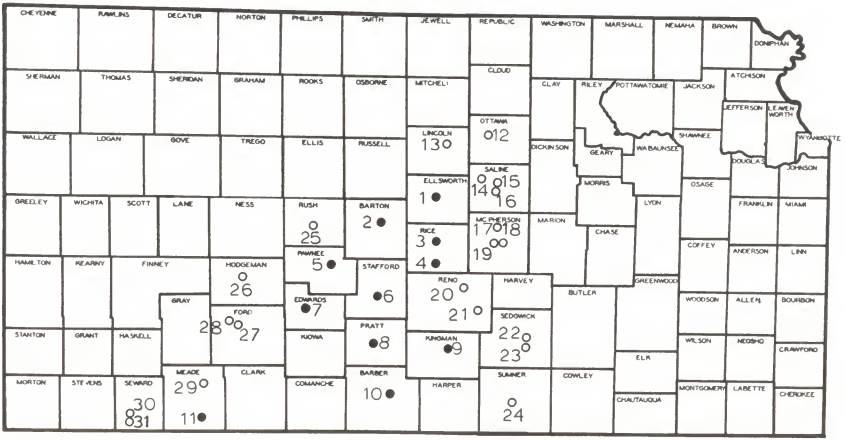
The numbers 1 - 31 denote locations checked for possible locations of Surattha indentella in Kansas. Solid circles, 1 - 11, represent locations where infestations have been observed. Open circles, 12 - 31, represent locations where Surattha indentella have not been observed.

1. Ellsworth Country Club, Ellsworth County.
2. Alois Demel farm yard, 2 miles north and 2 miles west of Redwing, Barton County.
3. Lyons Town and Country Club, Rice County.
4. Sterling Golf Course, Rice County.
5. Larned Country Club, Pawnee County.
6. Stafford County Country Club, Stafford County.
7. Kinsley Golf Course, Edwards County.
8. Pratt Country Club, Pratt County.
9. Kingman Golf Course, Kingman County.
10. Medicine Lodge Country Club, Barber County.
11. Otis Meredith farm yard, 16 miles south and 1 1/2 miles west of Meade on Kansas Highway 23, Meade County.
12. Minneapolis Golf Course, Ottawa County.
13. Lincoln Golf Club, Lincoln County.
14. Hedville Heights Golf Acres, Saline County.
15. Salina Country Club, Saline County.
16. Elks Country Club, Saline County.
17. Lindsborg Golf Club, McPherson County.
18. Rolling Acres Golf Club, McPherson County.
19. McPherson Country Club, McPherson County.
20. Carey Park Golf Club, Reno County.

EXPLANATION OF PLATE III (concl.)

21. Haven Golf Club, Reno County.
22. Clapp Park Golf Course, Sedgwick County.
23. Rolling Hills Country Club, Sedgwick County.
24. Wellington Municipal Golf Course, Sumner County.
25. Lacrosse Country Club, Rush County.
26. Jetmore Country Club Inc., Hodgeman County.
27. Dodge City American Legion Golf Course, Ford County.
28. Dodge City Country Club, Ford County.
29. Meade Golf Course, Meade County.
30. Liberal Country Club, Seward County.
31. Liberal Municipal Country Club, Seward County.

PLATE III


CHEYENNE
RAWLINS
DECATUR
NORTON
PHILLIPS
SMITH
JEWELL
REPUBLIC
WASHINGTON
MARSHALL
NEMAHA
BROWN
DONIPHAN
SHERMAN
THOMAS
SHERIDAN
GRAHAM
ROOKS
OSBORNE
MITCHELL
CLOUD
CLAY
RILEY
POTTAWATOMIE
JACKSON
ATCHISON
JEFFERSON
LEAVENWORTH
WYANDOTTE
WALLACE
LOGAN
GOVE
TREGO
ELLIS
RUSSELL
LINCOLN
OTTAWA
DICKINSON
GEARY
WABAUNSEE
SHAWNEE
DOUGLAS
JOHNSON
ELLSWORTH
SALINE
MORRIS
OSAGE
GREELEY
WICHITA
SCOTT
LANE
NESS
RUSH
BARTON
MARION
LYON
FRANKLIN
MIAMI
RICE
MCPHERSON
CHASE
COFFEY
ANDERSON
LINN
HAMILTON
KEARNY
FINNEY
HODGEMAN
PAWNEE
STAFFORD
HARVEY
GREENWOOD
BUTLER
WOODSON
ALLEN
BOURBON
GRAY
EDWARDS
RENO
SEDGWICK
FORD
PRATT
KINGMAN
STANTON
GRANT
HASKELL
KIOWA
WILSON
NEOSHO
CRAWFORD
ELK
MEADE
BARBER
SUMNER
MORTON
STEVENS
SEWARD
CLARK
COMANCHE
HARPER
COWLEY
MONTGOMERY
LABETTE
CHEROKEE
CHAUTAUQUA

## Life History Study

Distribution. Areas in central and western Kansas and Oklahoma were surveyed for possible locations of S. indentella infestations (Plate I). After the first two infestations of S. indentella were found in buffalograss on golf course fairways, a list of golf courses was compiled. Selection of golf course locations from the list was a great help in defining the distribution of S. indentella.

In addition, some buffalograss lawns, pastures, cemeteries, parks, highway right-of-ways, and airfields within the suspected distribution area were also surveyed. Occasionally, other potential host grasses were checked.

This organized survey was conducted in July, 1967 when possible infestation sites could more readily be determined by the presence of larvae and their excavations.

Surface characteristics of S. indentella infestations were used first in covering large areas of buffalograss. Sod plugs were also examined to more accurately determine the presence or absence of S. indentella. The presence of larvae was a positive indication, while absence indicated there were no larvae in the small sample taken.

Rearing Methods. A number of rearing methods and techniques was employed in this study to obtain a laboratory population from which observations could be made. The methods used were those most effectively employed for other sod webworms (Ainslie, 1930).

Field collected larvae were placed in both pots and flats containing buffalograss. In addition, larvae were placed in salve tins

floored with slightly moistened filter paper. Salve tins containing a layer of sand also were used. Large cork-stoppered vials containing soil were used to observe larval habits in tunnel construction. In both vials and salve tins, fresh pieces of buffalograss were supplied daily. Several first instar larvae were placed in a cage used in studying soil insects (Peterson, 1964). This cage consisted of a wooden bottom and wooden ends into which were cut two grooves spaced one inch apart. Two panes of glass were slid into these grooves creating a narrow area which was filled with soil and seeded with buffalograss.

A reinforced screened top was placed over a flat of infested turf from the Larned Country Club to collect adults for identification.

An artificial diet was used in attempting to rear larvae through adulthood (Wellington, 1949). Larvae were reared at 80°F. and 70 per cent relative humidity. A modification of Wellington's diet was used:

100 parts - Buchloe dactyloides foliage

4 parts - agar

400 parts - distilled water

2 parts - autolyzed yeast

2 parts - Mycoban (calcium propionate), (mold inhibitor)

Blades of buffalograss were cut, dried in an oven for four hours and finely ground in a Wiley cutting mill. The agar, yeast, and mycoban were placed in a measured volume of boiling water and thoroughly mixed. The powdered foliage was slowly added to the solution with constant stirring. The hot, well-mixed ingredients were poured into plastic jelly cups. The diet was allowed to cool, placed in a high moisture container and held in a refrigerator until used.

Sampling Technique. To obtain a constant supply of larvae used in determining the stages of S. indentella, their dates of occurrence and larval growth, sod samples were taken at approximately weekly intervals after larval activity was first observed at the Ellsworth and Larned Country Clubs in April, 1967.

Five samples were taken from each of three sites, namely Fairway two, six, and Rough two, at the Larned Country Club. Five samples were taken from Fairway six at the Ellsworth Country Club. In all cases samples were taken in approximately the same site.

Samples consisted of four inch diameter sod plugs taken approximately weekly throughout the active period. Samples were taken with a standard scalloped edged golf course hole cutter until the ground became too hard for penetration to desired depths, at which time a "sharp-shooter" or drain spade was used approximating a four inch diameter plug. Sod plugs were wrapped in newspapers and labeled as to date, site, and location. Samples were taken to the laboratory and stored in a refrigerator at approximately 40°F. until they could be examined. Samples were then carefully broken by hand, with the number, stage and depth recorded.

Observations on overwintering instar larvae were obtained by sampling on November 26, 1966, and January 30, 1967, and March 22, 1967.

Separation of Eggs and First Instar Larvae from the Soil. Sod plugs, four inches in diameter and three inches in depth, were taken at the Larned Country Club on August 25, September 1, 11, 25, and October 13, 1967. These samples were first broken into small particles by hand and

examined for eggs and first instar larvae. Once broken, the samples were wrapped in newspapers and stored in a freezer until processing.

The soil containing eggs and first instar larvae was separated from grass and other debris by sifting it through a screen having three openings per centimeter into a one-gallon glass jar. Water was added, and this mixture was shaken before being poured into a soil washing device. A two-screen washing device was employed for separation of the eggs from the mixture. However, only the larger upper screen of 60 mesh (0.6 mm. openings) was used. The mixture was poured into this screen; and, while the screen was rotated slowly by hand, water was sprayed over the mixture from two nozzles (10 gal. fan type) at a pressure of 15 psi. for several minutes. The contents were then poured through a screen having seven openings per centimeter and washed lightly with a hose to wash finer soil particles and eggs into a gallon jar. Collected suspension was then washed through a screen of 80 mesh (0.27 to 0.33 mm. openings) retaining eggs and first instar larvae. Material retained was then washed into a quart Mason jar and later thoroughly and carefully examined for eggs and first instar larvae.

Measurements. Measurements were made with the aid of an ocular micrometer in a Spencer binocular microscope with objectives powered 10X, 15X, 20X, 30X, and 40X and ocular with 15X magnification. Micrometer units were then converted to millimeters.

Adult. Half hour and hourly collections were taken from a black-light insect trap on the nights of August 10, 16, and 24, 1967 to determine adult peak flight activity.

Attempts to initiate feeding in the laboratory and field with water and a honey solution failed. No feeding on flowers and water in the field was observed even when Petri dishes containing water and a honey solution were placed in the field.

Mating was observed in the field but not in the laboratory.

Observations of natural oviposition were made by flashlight at the Larned Country Club on the nights of August 31, and September 11, 1967. Length of the oviposition period for unmated and mated females at 80°F. and a relative humidity of 70 per cent was determined by daily observations in the laboratory.

Females reared on artificial diet in the laboratory or newly emerged from infested sod were used for studies on the number of eggs laid by unmated females. Copulating pairs at Larned Country Club were placed in plastic jelly cups[1] and brought to the laboratory to determine the number of eggs laid each day following mating. The pairs were held in a rearing room at 80°F. and a relative humidity of 70 per cent. A few small holes were punctured in the cap of the cup to allow air to enter and the cup was inverted. Most of the eggs were laid in the crack around the inside of the cap. Moths were transferred to a clean cup daily.

Population duration in the field was determined by approximately weekly observations. Longevity of adult moths was determined by daily observations of each insect reared on artificial diet, captured in screen cage and removed daily, or copulating pairs collected in the field.

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[1]Premium Plastics Co., 2440 S. Indiana Ave., Chicago, Ill., No. 6916.

Egg. Eggs were kept in plastic jelly cups in a rearing room at 80°F. and 70 per cent relative humidity and examined daily to study the incubation period.

Fertile eggs were obtained from mating females captured in the field. Infertile eggs were obtained from newly emerged female moths from infested sod, and from female moths reared on artificial diet or in salve tins.

Larva. Larval growth was determined from measurements of larvae collected at approximately weekly samplings taken during the growing season. Larvae were removed from sod plugs and killed in ethanol. About 50 larval head capsules were measured (at the widest point near the L seta) each week from April 22, 1967 to August 17, 1967. In addition to the weekly collections from April 22, 1967 to August 17, 1967, a number of overwintering first instar larvae were collected and measured during the winter of 1966-67 and spring of 1967.

Feeding behavior of larvae was determined from field observations, laboratory rearing on buffalograss in a growth chamber, or in a rearing room on artificial diet.

Field observations and laboratory studies were undertaken in an attempt to determine actual and potential host plants. Partially grown larvae collected on June 28, 1967 were caged on various grasses in pots in a growth chamber. They were kept in darkness for a short period, and then a day length of 16 hours was resumed. Infestations were made by placing one larva per pot in each of 5 pots with the following grasses:

Buffalograss - Buchloe dactyloides

Big bluestem - Andropogon gerardi

Sideoats grama - Bouteloua curtipendula

Japanese lawngrass - Zoysia japonica

Creeping bentgrass - Agrostis palustris

Annual ryegrass - Lolium multiflorum

Perennial ryegrass - Lolium perenne

Kentucky bluegrass - Poa pratensis

Bermudagrass - Cynodon dactylon

Chewings red fescue - Festuca rubra, var. commutata

Observations were made and those infestations not successful were reinfested. Additional early instar larvae were placed in plastic jelly cups, each containing an artificial diet with a different grass as a nutrient source.

Attempts to determine the amount of food consumed daily in the laboratory failed. Larvae collected throughout the summer of 1967 were placed in salve tins floored with filter paper or sand and supplied with measured blades of buffalograss daily. Only those larvae collected about 10 days prior to pupation in the field survived and pupated.

Approximately weekly throughout the larval period from April 22, 1967 to August 10, 1967, about 20 surface tubes were randomly selected at the Ellsworth and Larned Country Clubs and the length of each measured in millimeters, to determine the relationship of surface tube length and larval growth.

Pupa. The pupation date, site, and depth were determined through field observations and weekly sod samples. The length of the pupal stage was determined by daily observation of each insect kept in plastic jelly cups in a rearing room at 80°F. and a relative humidity of 70 per cent.

## RESULTS AND DISCUSSION

### Distribution

Fifty-six observations, mostly on buffalograss golf course fairways, at different locations in thirty-six counties in Kansas were made during June and July, 1967. Infestations were found at eleven sites (Plate III) as follows:

Barber County
Medicine Lodge Country Club

Barton County
Alois Demel, farm yard

Edwards County
Kinsley Golf Course

Ellsworth County
Ellsworth Country Club

Kingman County
Kingman Golf Course

Meade County
Otis Meredith, farm yard

Pawnee County
Larned Country Club

Pratt County
Pratt Country Club

Rice County
Lyons Town and Country Club
Sterling Golf Course

Stafford County
Stafford County Country Club

Forty-five locations in Kansas surveyed and where infestations of S. indentella were not observed are listed in the Appendix. Only those locations encircling known infestations are shown in Plate III.

A survey conducted in Oklahoma in July, 1967 indicated S. indentella to be present in the Pan Handle (PH), NW and WC Oklahoma on golf course fairways containing buffalograss (Plate I). The infestation in Beaver County was on a home lawn containing bermudagrass with a previous history of buffalograss. S. indentella infestations were observed at the following nine locations in Oklahoma:

Beaver County (PH)
Beaver, home lawn

Beckham County (WC)
Elk City Golf and Country Club
Sayer Country Club

Blaine County (WC)
Roman Nose State Park Golf Course

Dewey County (WC)
Seiling Golf Course

Ellis County (NW)
Shattuck Golf Course

Major County (NW)
Fairview Golf Course

Woods County (NW)
Waynoka Golf Course

Woodward County (NW)
Woodward Country Club

S. indentella infestations were not observed at ten locations in Oklahoma in July, 1967. These are listed in the Appendix.

## Adult

Sex Differences. Male moths, according to Kearfott (1908) are light to dark smoky ochreous brown in color, while female moths are lighter in color. Males are smaller than females with a length of about 12 mm. and a wing expanse of about 21 mm. compared to the larger female moths with a length of about 15 mm. and wing expanse of about 30 mm. Male moths have bipectinate antennae, while female moths have filiform antennae.

Activity Period. Moths were observed to be active during a period beginning at dusk, reaching a peak about sunset, and gradually tapering off several hours after sunset. On the nights of August 10, 16 and 24, 1967 a black-light insect trap was run at the Larned Country Club to detect flight periods. Half hour and hourly collections on August 10, 1967 beginning at 7:00 P.M. and running through 7:00 A.M. resulted in a total collection of seven male moths. Six male moths were collected between 9:00 P.M. and 9:30 P.M., and one male moth was collected between 11:00 P.M. and 12:00 P.M. A low population was given as the reason for such a low recovery. Half hour and hourly collections taken from 7:00 P.M. to 7:00 A.M. on August 16, 1967 resulted in no moths collected. Observations earlier had indicated that moth population was high. Explanation for no moths collected lies in the fact that at 8:30 P.M. a heavy shower, lasting about an hour and one half with an accumulation of one and one-half inches occurred at about the time moths were most active. This shower evidently curtailed flight activity that evening. Half hour and hourly collections taken from 7:00 P.M. to 7:00 A.M. on August 24, 1967 gave

more conclusive results. These results, represented in Table 1, indicated that males were more attracted to black-light than females, and that the attractive period began about dusk and reached a peak about sunset or shortly thereafter, and then gradually tapered off in early morning.

Incandescent lights from a nearby shed, and automobile head lights were observed to exert no attraction to S. indentella moths, as none were seen flying around them.

Daily light trap collections taken from August 10, 1967 to September 11, 1967 proved little, as management with closer attention and immediate sorting of collected material was infeasible, even in weekly trips.

Though few female moths were collected in a black-light trap, many females were observed fluttering around the base of the trap. Female moths seemed to be attracted, but incapable of flying to a height of two feet above the ground to be captured in the trap.

Adults were difficult to detect in nature because their coloration blended well with their habitat. Attempts were made to discover where adult moths were during the day. Many adults could be found lying listless in buffalograss fairways during the day. These moths in excellent condition were presumed to be newly emerged adults. Adjacent grassy and weedy areas were swept during the day, with only a few adult moths being collected. Evergreen shrubs, lining the fairways, were examined, but proved negative. The possibility exists that adult moths seek concealment at the bases of adjacent tall grasses.

Table 1. Number of S. indentella adults collected in a black light insect trap at the Larned Country Club the night of August 24-25, 1967.

| Time interval | Sex | | Number of moths collected |
|---|---|---|---|
| | Male | Female | |
| 6:30 P.M. - 7:00 P.M. | - | - | 0 |
| 7:00 P.M. - 7:30 P.M. | - | - | 0 |
| 7:30 P.M. - 8:00 P.M. | - | - | 0 |
| 8:00 P.M. - 8:30 P.M. | - | - | 0 |
| 8:30 P.M. - 9:00 P.M. | 26 | 1 | 27 |
| 9:00 P.M. - 9:30 P.M. | 23 | - | 23 |
| 9:30 P.M. - 10:00 P.M. | 44 | - | 44 |
| 10:00 P.M. - 10:30 P.M. | 13 | - | 13 |
| 10:30 P.M. - 11:00 P.M. | 13 | - | 13 |
| 11:00 P.M. - 11:30 P.M. | 8 | - | 8 |
| 11:30 P.M. - 12:00 P.M. | 3 | - | 3 |
| 12:00 P.M. - 12:30 A.M. | 5 | - | 5 |
| 12:30 A.M. - 1:00 A.M. | 3 | 1 | 4 |
| 1:00 A.M. - 2:00 A.M. | 2 | - | 2 |
| 2:00 A.M. - 3:00 A.M. | - | - | 0 |
| 3:00 A.M. - 4:00 A.M. | - | - | 0 |
| 4:00 A.M. - 5:00 A.M. | - | - | 0 |
| 5:00 A.M. - 6:00 A.M. | - | - | 0 |
| 6:00 A.M. - 7:00 A.M. | - | - | 0 |
| 7:00 A.M. - 8:00 A.M. | - | - | 0 |

Feeding. Adults at no time, either in the field or in the laboratory when offered water or a honey solution, were observed to feed. Thus, the necessity for feeding prior to oviposition remains doubtful.

Mating. Mating was observed in the field, but never in the laboratory, even when adults were placed at high numbers in a gallon glass jar. On the night of August 24, 1967 mating was first observed one half hour following sunset, and last observed two hours later. At 9:00 P.M. on the night of August 26, 1967 a male and female were observed in copulation. When a jelly cup was placed over them, immediate separation resulted. Several adults observed mating separated immediately when captured. One such pair captured immediately separated only to be observed copulating again. Another pair captured and confined in a jelly cup were observed copulating again following disturbance and separation, even after a few eggs had been deposited.

The position of the mating pair was horizontal, tail-to-tail with the distal parts of the male's wings usually overlapping the female's wings. Females were observed on several occasions to drag the smaller males around while still united. However, there was usually little or no movement.

The age and frequency of mating were not determined in this study.

Oviposition. Females were observed ovipositing at the Larned Country Club on the nights of August 31, and September 11, 1967. Oviposition was observed to take place about dusk and continue on into the early hours of the morning. Females observed ovipositing would scurry over grass almost incapable of flight, stopping in barren areas where they would arch their abdomen, middle legs raised. Once in

position, repeated movements of the ovipositor in digging into the ground were responsible for eggs laid to depths of one-fourth to one-half inch. Females would then scurry a short distance, usually less than one inch, and repeat the procedure, laying another egg. Females confined in jelly cups were observed franctically trying to dig into the inside of the cap with their robust ovipositor.

Eggs found in the field were laid singly. However, one cluster containing 42 eggs was found in the field. Eggs laid in jelly cups where space was limited were found molded together in an overlapping fashion around the edges of the plastic cups.

Mated females tended to oviposit over a shorter period than unmated females. The average oviposition period in the laboratory lasted an average of 2.34 days with a range of 1 to 4 days for 35 fertilized females examined (Table 2) compared to an average of 5.21 days and a range of 1 to 7 days for 14 unmated females (Table 3).

Mated females tended to lay more eggs than unmated females. The fecundity of 35 fertilized females ranged from 4 to 175, with an average of 83.69 eggs deposited per female (Table 2) compared to a range of 12 to 50, with an average of 23.93 eggs deposited for 14 unmated females (Table 3). One unmated female contained in a plastic jelly cup was observed to lay no eggs. Upon placing a male in the cup, the male flew wildly, evidently trying to escape. The female immediately became excited and deposited several eggs.

Longevity. Adult population duration in the field at the Larned Country Club was determined to be about two months, ranging from August 4, to September 25, 1967. Of 56 unmated males and 30 unmated females

Table 2. Oviposition records from day of mating of 35 fertilized females of S. indentella at 80 degrees Fahrenheit and a relative humidity of 70 per cent.

| Female No. | Number of eggs laid Days after mating of adult females | | | | Total |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | |
| 1. | 134 | 4 | | | 138 |
| 2. | 79 | 39 | 2 | | 120 |
| 3. | 84 | 10 | 0 | | 94 |
| 4. | 92 | 7 | 3 | | 102 |
| 5. | 103 | 0 | 0 | | 103 |
| 6. | 136 | 0 | | | 136 |
| 7. | 93 | | | | 93 |
| 8. | 69 | | | | 69 |
| 9. | 76 | 0 | 13 | 5 | 94 |
| 10. | 105 | 21 | 9 | | 135 |
| 11. | 83 | | | | 83 |
| 12. | 90 | 1 | 0 | | 91 |
| 13. | 97 | 0 | | | 97 |
| 14. | 38 | 1 | | | 39 |
| 15. | 87 | 0 | | | 87 |
| 16. | 72 | 5 | | | 77 |
| 17. | 126 | 0 | 0 | 0 | 126 |
| 18. | 116 | 22 | 1 | | 139 |
| 19. | 90 | 0 | | | 90 |
| 20. | 4 | 4 | 2 | | 10 |
| 21. | 83 | 7 | 1 | | 91 |
| 22. | 0 | 0 | 4 | | 4 |
| 23. | 94 | 3 | | | 97 |
| 24. | 163 | 0 | 12 | | 175 |
| 25. | 0 | 10 | 0 | | 10 |
| 26. | 53 | 0 | | | 53 |
| 27. | 109 | 14 | 0 | | 123 |
| 28. | 72 | 8 | | | 80 |
| 29. | 33 | 0 | | | 33 |
| 30. | 8 | 0 | | | 8 |
| 31. | 54 | | | | 54 |
| 32. | 117 | 0 | | | 117 |
| 33. | 3 | 4 | | | 7 |
| 34. | 83 | | | | 83 |
| 35. | 47 | 24 | | | 71 |
| Total | 2693 | 184 | 47 | 5 | 2929 |
| Average per cent | 91.94 | 6.28 | 1.61 | 0.17 | 83.69 |

Table 3. Oviposition records from day of emergence of 14 unmated females of S. indentella at 80°F. and a relative humidity of 70 per cent.

| Female No. | Number of eggs laid: Days after emergence of adult females | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
| 1 | 14 | -[a] | | | | | | 14 |
| 2 | 0 | 0 | 0 | 16 | 1 | 0 | -[a] | 17 |
| 3 | 0 | 0 | 0 | 0 | 0 | 1 | 21 | 22 |
| 2Jy29 | 0 | 3 | 7 | 5 | 0 | -[a] | | 15 |
| 8Jy29 | 1 | 0 | 0 | 11 | 6 | 21 | 6 | 45 |
| 7Au4 | 3 | 1 | 8 | 1 | -[a] | | | 13 |
| 10Au10 | 0 | 0 | 1 | 4 | 5 | 5 | 14 | 29 |
| 13Au10 | 0 | 0 | 0 | 1 | 12 | 23 | -[a] | 36 |
| 16Au10 | 0 | 1 | 1 | 1 | 3 | 9 | 5 | 20 |
| 3Au17 | 0 | 0 | 0 | 0 | 0 | 12 | 0 | 12 |
| 13Au17 | 0 | 0 | 0 | 14 | 3 | 0 | -[a] | 17 |
| 16Au17 | 0 | 0 | 0 | 0 | 1 | 7 | 16 | 24 |
| 1Au25 | 2 | 14 | 5 | -[a] | | | | 21 |
| 3Au25 | 50 | -[a] | | | | | | 50 |
| Total | 70 | 19 | 22 | 53 | 31 | 78 | 62 | 335 |
| Average | 5.00 | 1.36 | 1.57 | 3.79 | 2.21 | 5.57 | 4.43 | 23.93 |
| Per cent | 20.90 | 5.67 | 6.57 | 15.82 | 9.25 | 23.28 | 18.51 | 100.00 |

[a] Individual found dead.

observed in the laboratory at a temperature of 80°F. and a relative humidity of 70 per cent, an average life span of 4.61 and 4.60 days, respectively, was obtained. The range for both unmated males and females being 1 to 9 days. Of 50 field collected pairs kept at a temperature of 80°F. and a relative humidity of 70 per cent, males lived an average of 3.26 days with a range of 1 to 7 days following mating, while females lived an average of 2.66 days with a range of 1 to 5 days following mating. Unmated males and females lived longer than mated males and females. However, there seemed to be no difference in sex longevity between unmated individuals, though mated males lived longer than mated females.

Days from emergence to mating were not determined.

## Egg

Eggs of S. indentella are white in color and pliable when first laid. Oval eggs are laid singly in the field at depths ranging from one-fourth to one-half inch. Fifty fertile eggs laid in jelly cups had an average width of 0.97 mm. with a range of 0.87 mm. to 1.06 mm., and an average length of 1.34 mm., with a range of 1.22 mm. to 1.44 mm. Fifty infertile eggs laid in jelly cups had an average width of 0.95 mm., with a range of 0.76 mm. to 1.06 mm., and an average length of 1.28 mm. with a range of 1.06 mm. to 1.41 mm. Fertile eggs were thus longer, but not wider than infertile eggs.

The number of eggs found in samples taken at Larned and Ellsworth Country Clubs approximately weekly from August 17 to October 13, 1967, are expressed in Tables 4 and 5, respectively. The number of eggs

Table 4. Number of eggs obtained in 4-inch diameter sod samples from Larned Country Club in 1967.

| Date | No. of samples | Number of eggs | | Total number of eggs |
|---|---|---|---|---|
| | | Range | Average | |
| 8/17 | 17 | 0 - 9 | 1.00 | 17 |
| 8/25 | 17 | 0 - 13 | 2.35 | 40 |
| 9/1 | 15 | 0 - 60 | 17.20 | 258 |
| 9/11 | 15 | 1 - 6 | 2.73 | 41 |
| 9/25 | 15 | 0 - 5 | 1.33 | 20 |
| 10/13 | 17 | -[a] | | |

[a] No eggs found.

Table 5. Number of eggs obtained in 4-inch diameter sod samples from Ellsworth Country Club in 1967.

| Date | No. of samples | Number of eggs | | Total number of eggs |
|---|---|---|---|---|
| | | Range | Average | |
| 8/17 | 5 | 0 - 4 | 0.80 | 4 |
| 8/25 | 5 | 0 - 2 | 0.60 | 3 |
| 9/1 | 6 | 0 - 2 | 0.83 | 5 |
| 9/11 | 5 | 0 - 4 | 1.80 | 9 |
| 9/25 | 5 | -[a] | | |
| 10/13 | 5 | -[a] | | |

[a] No eggs found.

recovered at the Ellsworth Country Club reached a peak on September 11, 10 days later than the number recovered at the Larned Country Club which reached a peak on September 1, 1967. However, egg development at the northern infestation, Ellsworth, caught up and passed egg development at the southern infestation, Larned.

The incubation period of 246 eggs at a temperature of 80°F. and a relative humidity of 70 per cent was an average of 12.26 days and ranged from 11 to 14 days.

## Larva

Growth. The growth of larvae, based on head capsule width and body length, is shown in Table 6. The rapid rate of head width change within about a week, indicates the importance of sampling at least once a week during the growing season to avoid missing an instar. The distance to the nearest infestation made more frequent sampling infeasible. The number of larval instars was not determined in this study.

The number of larvae found in samples taken at Larned and Ellsworth Country Clubs approximately weekly from April 22 through September 11, 1967 are expressed in Tables 7 and 8, respectively. Rapid drop and fluctuations in number of larvae in samples from the Larned Country Club in April and May substantiate observed mortality following cool rainy periods. Fluctuations throughout the months of June and July are believed normal variation in samples taken. Gradual drop of larvae obtained in the month of August indicates when pupation was taking place.

One insect was reared from first instar larvae through adulthood in a growth chamber at 80°F. on buffalograss planted in a soil cage. An

Table 6. Growth of field collected larvae, determined by head capsule width and body length measurements, expressed in millimeters.

| Date | Number measured | Average | |
|---|---|---|---|
| | | Head width | Body length |
| November 26, 1966 | 5 | 0.4940 | 2.1432 |
| January 30, 1966 | 31 | 0.4930 | 2.4363 |
| March 22, 1967 | 8 | 0.4940 | 2.1138 |
| April 22, 1967 | 61 | 0.7360 | 4.9791 |
| April 29, 1967 | 85 | 1.0890 | 6.4171 |
| May 6, 1967 | 49 | 0.9911 | 8.4931 |
| May 13, 1967 | 124 | 1.0876 | 7.7838 |
| May 20, 1967 | 49 | 1.2874 | 9.1268 |
| June 2, 1967 | 50 | 1.5458 | 12.1954 |
| June 12, 1967 | 37 | 1.8702 | 12.8776 |
| June 20, 1967 | 50 | 2.2078 | 16.5835 |
| June 26, 1967 | 50 | 2.2922 | 16.4331 |
| July 4, 1967 | 60 | 2.5124 | 19.4938 |
| July 14, 1967 | 55 | 2.5764 | 20.1951 |
| July 20, 1967 | 50 | 2.6397 | 20.5282 |
| July 29, 1967 | 50 | 2.5681 | 20.8971 |
| August 4, 1967 | 50 | 2.6494 | 20.0849 |
| August 10, 1967 | 50 | 2.5133 | 17.1089 |
| August 17, 1967 | 14 | 2.7279 | 17.5316 |

Table 7. Number of larvae obtained in 4-inch diameter sod samples from Larned Country Club in 1967.

| Date | No. of samples | Total No. of larvae | No. of larvae | |
|---|---|---|---|---|
| | | | Range | Average |
| 4/22 | 14 | 147 | 1 - 26 | 10.50 |
| 4/29 | 15 | 126 | 0 - 22 | 8.40 |
| 5/6 | 17 | 91 | 0 - 17 | 5.35 |
| 5/13 | 18 | 300 | 1 - 34 | 16.67 |
| 5/20 | 16 | 184 | 1 - 35 | 11.50 |
| 6/2 | 18 | 165 | 3 - 20 | 9.17 |
| 6/12 | 20 | 54 | 0 - 11 | 2.70 |
| 6/20 | 16 | 121 | 3 - 14 | 7.56 |
| 6/26 | 15 | 124 | 5 - 18 | 8.27 |
| 7/4 | 16 | 111 | 1 - 14 | 6.94 |
| 7/14 | 18 | 75 | 0 - 17 | 4.17 |
| 7/20 | 15 | 97 | 3 - 10 | 6.47 |
| 7/29 | 16 | 83 | 2 - 10 | 5.19 |
| 8/4 | 16 | 54 | 0 - 8 | 3.38 |
| 8/10 | 18 | 41 | 0 - 6 | 2.28 |
| 8/17 | 17 | 23 | 0 - 4 | 1.35 |
| 8/25 | 17 | 7 | 0 - 3 | 0.41 |
| 9/1 | 15 | 2 | 0 - 1 | 0.13 |
| 9/11 | 15 | -[a] | | |

[a] No larvae found.

Table 8. Number of larvae obtained in 4-inch diameter sod samples from Ellsworth Country Club in 1967.

| Date | No. of samples | Total No. of larvae | No. of larvae | |
|---|---|---|---|---|
| | | | Range | Average |
| 4/29 | 3 | 20 | 2 - 14 | 6.67 |
| 5/13 | 5 | 44 | 5 - 16 | 8.80 |
| 5/20 | 5 | 30 | 2 - 9 | 6.00 |
| 6/2 | 8 | 97 | 4 - 17 | 12.13 |
| 6/15 | 7 | 86 | 3 - 21 | 12.29 |
| 6/20 | 5 | 63 | 9 - 18 | 12.60 |
| 6/26 | 6 | 108 | 16 - 21 | 18.00 |
| 7/4 | 6 | 23 | 1 - 7 | 3.83 |
| 7/14 | 6 | 27 | 1 - 9 | 4.50 |
| 7/20 | 6 | 67 | 4 - 17 | 11.17 |
| 7/29 | 7 | 65 | 5 - 17 | 9.29 |
| 8/4 | 5 | 38 | 5 - 12 | 7.60 |
| 8/10 | 6 | 24 | 1 - 6 | 4.00 |
| 8/17 | 6 | 6 | 0 - 2 | 1.00 |
| 8/25 | 5 | 1 | 0 - 1 | 0.20 |
| 9/1 | 6 | -[a] | | |

[a] No larvae found.

overwintering first instar larva collected in the field on November 26, 1966 was placed in glass cage on December 12, 1966. Escavation followed by feeding was observed on the following day. Several blades of grass were cut and pulled, base first, down the surface tube and vertical tunnel. This larva extended the surface tube as food became scarce, until it extended the entire length of glass cage. Several plants were permanently denuded. On March 25, 1967, an adult female moth emerged. Following oviposition this moth died four days later on March 29, 1967. The duration from first instar larva to adult was 104 days. Countless attempts to rear additional first instar larvae to adults failed.

Surface and Tunnel Habits. Solitary larvae were observed to inhabit vertical tunnels in the soil. These tunnels consisted of hollow, smooth, silk-lined, circular holes extending to varying depths. Construction of these tunnels, as observed with larvae placed in glass vials containing soil, consisted of initial burrowing followed by larvae tying particles of soil together and rolling them around using their heads. Tunnels were made deeper and wider as larvae grew. Tunnels extending to depths of 18 inches were observed during the hot, dry summer of 1966. Depths of tunnels measured in millimeters at the Larned and Ellsworth Country Clubs during 1967 are shown in Tables 9 and 10, respectively. There was little difference in depth of larvae at both locations on successive dates. Larvae were observed to move equally well forward and backward in these vertical tunnels. A widened area near the base of the tunnel allowed for a place in which larvae could turn, as well as a temporary deposition for food and fecal material. Larvae were found in these tunnels during the day.

Table 9. Average depth in millimeters larvae were found in 4-inch diameter sod samples from Larned Country Club in 1967.

| Date | No. of larvae measured | Depth of larvae | |
|---|---|---|---|
| | | Range | Average |
| 4/22 | 61 | 15 - 30 | 23.92 |
| 4/29 | 49 | 10 - 50 | 26.45 |
| 5/6 | 46 | 10 - 41 | 27.59 |
| 5/13 | 110 | 20 - 60 | 35.72 |
| 5/20 | 78 | 20 - 60 | 35.58 |
| 6/2 | 69 | 40 - 80 | 53.48 |
| 6/12 | 23 | 40 - 90 | 52.30 |
| 6/20 | 53 | 45 - 110 | 66.13 |
| 6/26 | 49 | 40 - 95 | 61.53 |
| 7/4 | 66 | 40 - 90 | 66.36 |
| 7/14 | 28 | 55 - 100 | 71.25 |
| 7/20 | 48 | 35 - 100 | 70.83 |
| 7/29 | 42 | 45 - 100 | 71.43 |
| 8/4 | 24 | 50 - 110 | 74.58 |
| 8/10 | 16 | 60 - 95 | 78.44 |
| 8/17 | 10 | 45 - 95 | 77.70 |
| 8/25 | 2 | 70 - 75 | 72.50 |

Table 10. Average depth in millimeters larvae were found in 4-inch diameter sod samples from Ellsworth Country Club in 1967.

| Date | No. of larvae measured | Depth of larvae | |
|---|---|---|---|
| | | Range | Average |
| 4/29 | 7 | 20 - 35 | 28.57 |
| 5/13 | 17 | 20 - 55 | 35.88 |
| 5/20 | 15 | 30 - 50 | 39.67 |
| 6/2 | 24 | 45 - 95 | 59.58 |
| 6/15 | 26 | 35 - 90 | 64.62 |
| 6/20 | 27 | 43 - 90 | 59.37 |
| 6/26 | 61 | 40 - 120 | 61.15 |
| 7/4 | 11 | 50 - 95 | 68.18 |
| 7/14 | 10 | 50 - 80 | 63.50 |
| 7/20 | 44 | 50 - 90 | 72.00 |
| 7/29 | 29 | 45 - 90 | 69.48 |
| 8/4 | 19 | 55 - 95 | 74.47 |
| 8/10 | 11 | 55 - 100 | 77.27 |
| 8/17 | 3 | 50 - 90 | 63.75 |

Flexible, horizontal surface tubes were found extending from vertical tunnels. Usually, only a single surface tube was connected with each vertical tunnel, though overlapping was observed where infestations were heavy. Surface tubes were constructed by larvae from soil particles excavated from vertical tunnels, dried pieces of grass, grass stems and seed heads, fecal pellets and other material found on the soil surface. These materials were all interwoven with silk, forming a tube which was flexible but yet quite firm. Surface tubes were observed standing straight up into the air, and fastened to stems of grass but they were usually lying horizontal on the soil surface. Surface tubes were smooth on the inner surface because they were heavily lined with silk, while the exterior of the surface tubes blended with its surroundings. Larvae would add to the length of the surface tubes by incorporating any nearby material. One larva was observed removing particles from a neighboring surface tube. Surface tubes were feeding tubes in which larvae would remain sheltered while extending the tube until the end encountered a grass stem. As in vertical tunnels, larvae were observed to move equally well in both directions. Larvae were observed to use surface tubes during the dark hours. Many attempts to capture larvae in surface tubes were tried on the night of August 5, 1966. However, only one larva was caught in the surface tube at 8:30 P.M.

About twenty random measurements in millimeters of the length of surface tubes at the Larned and Ellsworth Country Clubs are expressed in Tables 11 and 12, respectively. As larval growth increased and food in turn became scarce, surface tubes were lengthened accordingly. Surface

Table 11. Length of surface tubes in millimeters measured at Larned Country Club during active period of larval stage in 1967.

| Date | Number measured | Length | |
|---|---|---|---|
| | | Average | Range |
| 4/22 | 13 | 7.9 | 5 - 43 |
| 4/29 | 4 | 26.3 | 10 - 50 |
| 5/13 | 43 | 13.2 | 6 - 45 |
| 6/20 | 12 | 39.2 | 15 - 52 |
| 6/26 | 15 | 42.5 | 20 - 75 |
| 7/3 | 15 | 69.9 | 38 - 98 |
| 7/20 | 18 | 47.7 | 22 - 100 |
| 7/29 | 20 | 87.1 | 65 - 140 |
| 8/4 | 20 | 59.3 | 40 - 76 |

Table 12. Length of surface tubes in millimeters measured at Ellsworth Country Club during active period of larval stage in 1967.

| Date | Number measured | Length | |
|---|---|---|---|
| | | Average | Range |
| 6/20 | 12 | 29.4 | 15 - 45 |
| 6/26 | 15 | 36.8 | 25 - 55 |
| 7/3 | 15 | 55.7 | 25 - 80 |
| 7/20 | 20 | 66.6 | 40 - 100 |
| 7/29 | 20 | 56.2 | 35 - 85 |
| 8/4 | 20 | 79.2 | 50 - 110 |
| 8/10 | 20 | 54.9 | 25 - 75 |

tubes at the Larned Country Club reached a peak average length of 87.1 mm. on July 29, 1967 compared to a length of 79.2 mm. on August 4, 1967 at the Ellsworth Country Club. This further indicated that development at the Ellsworth infestation is 7 to 10 days later than development at the Larned infestation. Peak average length corresponds to a period of time just prior to major pupation period at both locations.

Feeding. It was not determined if first instar larvae feed prior to overwintering. It is the author's opinion that no feeding takes place prior to passing the winter. First instar larvae upon hatching from eggs placed in a soil cage containing buffalograss in a growth chamber were observed to move from panes of glass to the base of buffalograss. However, no feeding was observed.

Feeding in the field was observed from April 22, 1967 through the month of August. It was in mid-April, or shortly before, that buffalograss at the Larned Country Club was observed greening up. Observation, on the night of July 19, 1967 indicated that feeding first began at 9:45 P.M. and ended at 7:15 A.M. the following morning. Several larvae were observed reconstructing surface tubes prior to feeding. One larva, under careful examination, was observed to make several trips, each time clipping off a blade of grass and dragging it backwards down the surface tube and into the vertical tunnel. Apparently only food gathering takes place at night, with feeding occurring in the safe confines of the vertical tunnel during the day. One larva was observed wandering over the surface, evidently lost. This larva eventually found an empty tunnel into which it disappeared. A unique device was observed to be employed

by several larvae in closing or plugging the junction of the vertical tunnel and horizontal tube. At this junction, larvae would pull down the surface tube and tie it with silk, thus blocking the vertical tunnel in which they retreated.

Host Plants. Field observations indicated that S. indentella infestations were found primarily on lawns and golf course fairways containing buffalograss. An infestation was observed on Ellsworth Country Club bentgrass greens, which had a previous history of buffalograss. An infestation was observed on a bermudagrass lawn which also had a previous history of buffalograss.

Laboratory studies were undertaken in an attempt to determine potential host range. Partially grown larvae collected on June 28, 1967 were very difficult to establish in pots in a growth chamber containing the following grasses:

| | | |
|---|---|---|
| Buffalograss | - | Buchloe dactyloides |
| Big bluestem | - | Andropogon gerardi |
| Sideoats grama | - | Bouteloua curtipendula |
| Japanese lawngrass | - | Zoysia japonica |
| Creeping bentgrass | - | Agrostis palustris |
| Annual ryegrass | - | Lolium multiflorum |
| Perennial ryegrass | - | Lolium perenne |
| Kentucky bluegrass | - | Poa pratensis |
| Bermudagrass | - | Cynodon dactylon |
| Chewings red fescue | - | Festuca rubra, var. commutata |

Of 50 pots, 5 pots of each of 10 grasses, only in 3 pots were larvae reared to adulthood. Two adult females were found in early September, one on bermudagrass and the other on perennial ryegrass. One live adult male was found on zoysia grass on September 7, 1967.

First instar larvae were placed in plastic jelly cups, each containing an artificial diet with a different grass as a nutrient source. In addition, five test tubes each containing diets made from the same 10 grasses were infested with day-old larvae and placed in a rearing room at 80°F. and a relative humidity of 70 per cent. No larvae were reared through adulthood, as mold developed in every tube. Mold seems to be the biggest problem in working with artificial diet as it was encountered on numerous occasions, even though standard sterilization techniques were employed.

Attempts to determine the amount of food consumed daily in the laboratory failed because the larvae failed to feed on pieces of buffalograss freshly cut daily. Only those larvae collected in the field in late July survived and pupated.

Samples taken in the field on November 26, 1966, January 30, 1967, and March 22, 1967 indicated that Surattha indentella overwintered as first instar larvae. Upon hatching from eggs, first instar larvae are believed to move to the base of grass plants and dig into the ground to a depth of one-fourth to one-half inch and there hollow out a cell into which they curl and pass the winter. Whether this insect passes through true diapause or hibernation was not determined in this study.

## Pupa

Pupae were collected in the field as well as from larvae reared in the laboratory. In the field in 1967, pupation began in late July, and ended in early September (Plate IV).

Distribution. Pupae were found in samples taken at the Larned Country Club on July 29, 1967 through September 1, 1967. Samples taken on August 10, 17, 25, 1967 were found to contain the most pupae, with an average of 1 pupa per sod plug found on each of the three dates.

Pupae were found in a vertical position at varying depths in the same vertical tunnels they inhabited as larvae. The average depths in millimeters of pupae found in 4-inch diameter sod samples from the Larned and Ellsworth Country Clubs in 1967 are expressed in Tables 13 and 14, respectively. Pupae measured from Ellsworth samples seemed to be deeper than those pupae measured from Larned samples. There is little difference in the width and length of pupae between males and females, as well as collection site as expressed in Table 15. However, female pupae are slightly longer than male pupae (Plate V).

Observations on larvae placed in vials indicate that adults upon emergence from pupae crawl up and out of the vertical tunnels they inhabited as larvae.

Length of Pupal Stage from Laboratory Studies. Daily observations were made to determine the length in days of the pupal stage of larvae reared on artificial diet at 80°F. and a relative humidity of 70 per cent. Of 8 male pupae observed, an average length of 12.25 days was spent in the pupal stage, as compared to an average length of 12.42

## EXPLANATION OF PLATE IV

Seasonal occurrence of the stages of *Surattha indentella* Kearfott in south-central Kansas.

Note break in Figure between September and April, representing cold months when no development occurred.

PLATE IV

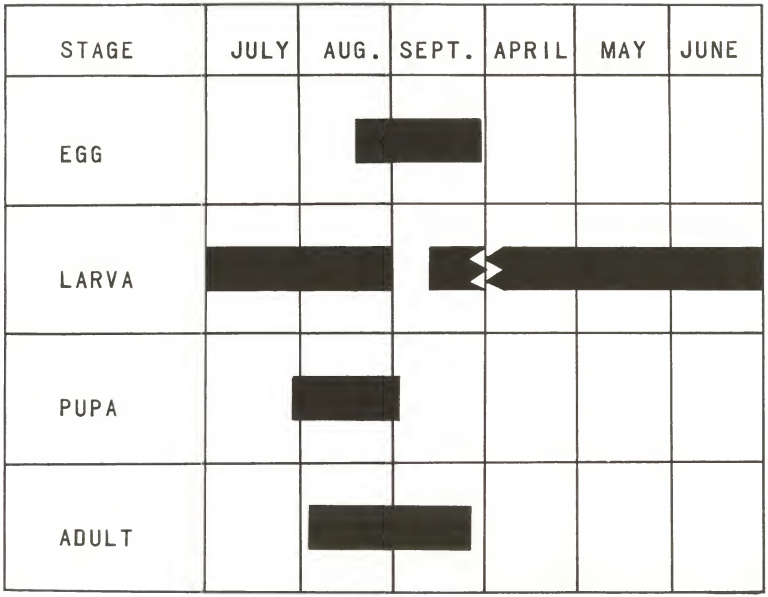

Table 13. Average depth in millimeters pupae were found in 4-inch diameter sod samples from Larned Country Club in 1967.

| Date | Number of pupae measured | Depth of pupae | |
|---|---|---|---|
| | | Range | Average |
| 7/29 | 1 | - | 55.00 |
| 8/4 | 2 | 20 - 35 | 27.50 |
| 8/10 | 8 | 20 - 60 | 37.50 |
| 8/17 | 11 | 12 - 70 | 38.55 |
| 8/25 | 4 | 5 - 40 | 28.75 |

Table 14. Average depth in millimeters pupae were found in 4-inch diameter sod samples from Ellsworth Country Club in 1967.

| Date | Number of pupae measured | Depth of pupae | |
|---|---|---|---|
| | | Range | Average |
| 8/17 | 3 | 25 - 85 | 55.00 |
| 8/25 | 2 | 30 - 50 | 40.00 |
| 9/1 | 1 | - | 60.00 |

Table 15. Average width and length of pupae collected at various locations in 1967, expressed in millimeters.

| Location | Date | Sex | Number measured | Width | | Length | |
|---|---|---|---|---|---|---|---|
| | | | | Range | Average | Range | Average |
| Larned | 8/25 | ♂ | 16 | 2.87 - 3.57 | 3.14 | 10.46 - 13.95 | 11.69 |
| " | " | ♀ | 3 | 3.33 - 3.41 | 3.38 | 13.56 - 14.57 | 14.03 |
| Demel | " | ♂ | 5 | 3.10 - 3.57 | 3.33 | 11.78 - 12.79 | 12.39 |
| " | " | ♀ | 1 | - | 3.95 | - | 18.21 |
| Ellsworth | " | ♂ | -[a] | | | | |
| " | " | ♀ | 4 | 3.33 - 3.57 | 3.47 | 13.80 - 15.73 | 14.40 |
| Artificial diet | - | ♂ | 16 | 2.56 - 3.33 | 3.03 | 9.69 - 13.41 | 11.95 |
| " | - | ♀ | 11 | 3.18 - 3.95 | 3.59 | 13.56 - 17.05 | 14.87 |
| Salve tins | - | ♂ | 6 | 2.71 - 3.49 | 3.01 | 9.30 - 13.18 | 11.28 |
| " | - | ♀ | 5 | 3.26 - 4.11 | 3.63 | 13.95 - 18.99 | 15.55 |

[a] No male pupae found.

EXPLANATION OF PLATE V

Fig. 1. Eggs in various stages of incubation. About 8 times natural size.

Fig. 2. Lateral view of last instar larva. About 3 1/2 times natural size.

Fig. 3. Upper, ventral view of male pupa; lower, lateral view of female pupa. About 4 1/2 times natural size.

Fig. 4. Left, adult female moth; right, adult male moth. About 1 1/2 times natural size.

PLATE V

Fig. 1

Fig. 2

Fig. 3

Fig. 4

days of 12 females observed. In both male and female pupae a range of 11 to 14 days in the pupal stage was observed. Length of the pupal stage in the field was not determined.

## Life History

The data collected indicated there is a single generation of Surattha indentella Kearfott a year in Kansas (Plate IV). Larvae were found throughout 1967. However, one generation lacked 7-10 days of overlapping the succeeding generation. Pupae were found on July 29, 1967 through September 1, 1967. Adults were observed from August 4, 1967 through September 25, 1967, with peak emergence in late August. Due to low population of adults, and small sample taken, eggs were not found until August 17, 1967. Eggs were found through September 25, 1967. Overwintering first instar larvae were first found on September 11, 1967.

The eggs, larva, pupae and adults are shown in Plate V.

## SUMMARY

The habits and life history of Surattha indentella Kearfott, and the taxonomic relationship, economic importance, and distribution is described and illustrated.

There is little published information available on S. indentella, other than the original description by Kearfott on October 31, 1908.

The economic importance of S. indentella, though difficult to estimate with any degree of accuracy, is nonetheless extensive. The

damage observed during the summer of 1966 to buffalograss turf by S. indentella demands resorting to costly replacement or renovation measures.

Damage consists of repeated defoliation of blades of grass through the months of June and July. Barren areas appear followed by gradual succession of weeds and other undesirable grasses.

S. indentella was observed principally on buffalograss fairways and lawns in eleven locations in south-central Kansas, and in nine locations in Oklahoma. S. indentella was also found on bentgrass greens and bermudagrass lawns with a previous history of buffalograss.

Adults are present in August and September. Adults mate in a tail-to-tail horizontal position. Mated males lived about one day longer than mater females. Oviposition occurs in barren areas. The average oviposition period in the laboratory lasted an average of 2.34 days with a range of 1 to 4 days for 35 fertilized females. Mating females were brought to the laboratory to study fecundity. An average of 83.69 eggs per female with a range of 4 to 175 was laid by mated females. Eggs were laid singly in the field during August and September to a depth of one-fourth to one-half inch. The incubation period ranged from 11 to 14 days, with majority hatch 12.26 days after oviposition when maintained at a constant temperature of 80°F. and a relative humidity of 70 per cent.

Larvae were found about eleven and one-half months out of the year in 1967. One first instar larva took 104 days to reach the adult stage in the laboratory at 80°F. Solitary larvae inhabit vertical tunnels

extending to depths up to 18 inches. Single horizontal surface tubes ranging from 5 to 140 mm. in length extend from vertical tunnels. Surface tubes constructed by larvae, are feeding tubes in which larvae remain sheltered until the end of the tube encountered a grass stem. Food gathering takes place at night, with feeding occurring in the safe confines of the vertical tunnels during the day. Larvae move equally well in both directions, in both vertical tunnels and surface tubes.

S. indentella has only a single generation a year, and overwinters as first instar larvae.

Pupation occurs within vertical tunnels at varying depths during August. The length of the pupal stage at a temperature of 80°F. and a relative humidity of 70 per cent averaged 12.25 and 12.42 days for males and females, respectively.

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# APPENDIX

S. indentella infestations were not observed at the following forty-five locations in Kansas in 1967.

Barton County

Lake Barton Golf Course

Great Bend Country Club

Clark County

Ashland Country Club

Comanche County

Coldwater Country Club

Dickinson County

Abilene Country Club

Ellis County

Fort Hays Country Club

Smoky Hill Country Club

Finney County

Garden City Country Club

Jaycees Airlinks Golf Course

Ford County

Dodge City Country Club

Dodge City American Legion Golf Course

Gray County

Cimarron Country Club

Greeley County

Tribune Golf Course

Hamilton County

Syracuse Golf Course

Harvey County

Halstead Golf Course

Newton Public Golf Course

Newton Country Club

Hodgeman County

Jetmore Country Club

Kearny County

Lakin Municipal Golf Course

Kiowa County

Greensburg Golf Course

Lincoln County

Lincoln Golf Course

Marion County

Hillsboro Municipal Golf Course

Peabody Golf Course

McPherson County

Lindsborg Golf Course

Rolling Acres Golf Course

McPherson Country Club

Meade County

Meade Golf Course

Ottawa County

Minneapolis Golf Course

Reno County

Haven Golf Course

Carey Park Golf Course

Rice County

Chase Golf Course

Riley County

Manhattan Country Club

Stagg Hill Golf Course

Rush County

Lacrosse Country Club

Saline County

Hedville Heights Golf Course

Elks Country Club

Salina Country Club

Scott County

Scott City Golf Course

Sedgwick County

Clapp Park Golf Course

Rolling Hills Country Club

Seward County

Liberal Municipal Golf Course

Liberal Country Club

Sumner County

Caldwell Golf Course

Wellington Municipal Golf Course

Wichita County

M. D. O'Brien pasture, 5 miles West and 10 1/2 miles South of Leoti

S. indentella infestations were not observed at the following ten locations in Oklahoma in July, 1967.

Blaine County

Watonga Golf Course

Custer County

Clinton Golf Course

Dewey County

Oakwood Country Club

Garfield County

University Golf Course

Harper County

Buffalo Golf Course

Laverne Golf and Country Club

Logan County

Guthrie Golf and Country Club

Roger Mills County

Cheyenne Golf Course

Texas County

Sunset Hills Golf Course

Hooker Golf Course

# THE HABITS AND LIFE HISTORY OF A PYRALID MOTH, *SURATTHA INDENTELLA* KEARFOTT, ATTACKING BUFFALOGRASS IN KANSAS. (LEPIDOPTERA: PYRALIDAE)

by

KENNETH ALAN SORENSEN

B. S., University of Rhode Island, 1966

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AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Entomology

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1968

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There is little published information available on S. indentella, other than the original description by Kearfott on October 31, 1908.

The economic importance of S. indentella, though difficult to estimate with any degree of accuracy, is none the less extensive. Extensive damage to buffalograss turf requires costly replacement or renovation measures.

Damage consists of repeated defoliation of blades of grass through the months of June and July. Barren areas appear, followed by gradual succession of weeds and other undesirable grasses.

S. indentella was observed principally on buffalograss fairways and lawns in eleven locations in south-central Kansas, and in nine locations in central Oklahoma. It was also found on bentgrass greens and bermudagrass lawns with a previous history of buffalograss.

Adults are present in August and September. Eggs are laid singly in the field to a depth of one-fourth to one-half inch during August and September. The incubation period ranged from 11 to 14 days, with majority hatch 12.26 days after oviposition.

Larvae were found about eleven and one-half months out of the year in 1967. Solitary larvae inhabit vertical tunnels extending to depths up to 18 inches. Single horizontal surface tubes extend from vertical tunnels. Surface tubes are feeding tubes up to 140 mm. long, in which larvae remain

sheltered until the end of the tube encounters a grass stem. Food gathering takes place at night, with feeding occurring in the safe confines of the vertical tunnels during the day. Larvae move equally well in both directions, in both vertical tunnels and horizontal tubes.

S. indentella has only a single generation a year, and overwinters as first instar larvae.

Pupation occurs within vertical tunnels during August. The length of the pupal stage was about 12 days at a constant temperature of 80°F. and a relative humidity of 70 per cent in a rearing room.