OBSERVATIONS ON *CRAMBUS* AND CLOSELY ALLIED FORMS IN KANSAS, WITH SPECIAL REFERENCE TO *CRAMBUS VULGIVAGELLUS* CLEM.

by

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INTRODUCTION

These observations on Crambus were begun in June, 1938, when prepupal cases were found in the ground beside grass clumps in an alfalfa field. The larvae within these prepupal cases were examined and tentatively identified as Nomophila noctuella D. & S., a Lepidopteran of the family Pyralididae, sub-family Pyraustinae. This insect is a minor pest of alfalfa and grasses.

When the adults emerged from the supposed Nomophila prepupal cases in September, 1938, they proved to be Crambus vulgivagellus Clem., which is also of the family Pyralididae, but in the sub-family Crambinae.

During the summer of 1938, frequent reports of damage to grasslands were received at the Entomology department of the Kansas State College of Agriculture and Applied Science. The greater part of this damage was attributed to Nomophila noctuella. Observations made on Crambus during the rest of the season tended to indicate that the damage was in part caused by the various species of Crambus.

A heavy flight of C. vulgivagellus at lights was experienced in Manhattan during the latter part of September, 1938. The moths were so abundant that they became pests at store fronts and street lights. It was this flight

that stimulated the interest of the writer to investigate the source of the moths, their type and the amount of damage the larvae would do.

The economic importance of Crambus to Kansas cannot be measured accurately because the insect is not known to the farmer and is seldom seen except in the adult stage. In grasslands, however, and perhaps in cultivated crops, there can be no doubt that, under heavy infestation, the damage by larvae is severe enough to reduce greatly the yield.

Nomophila noctuella, Acrolophus sp. and Stenoma mistrella in their various stages of development are oftentimes confused with Crambus. It is the purpose of this thesis to show structural and ecological differences between these species and Crambus sp. and to contribute to the bionomics of one of the common Crambids, Crambus vulgivagellus Clem.

REVIEW OF LITERATURE

Taxonomic Literature

Fabricius in 1798 established the genus Crambus, listing 62 species (Fernald, 1896). About 116 valid species are present in the literature now. Clemens (1860) described 12 new species. Grote (1880) published the first list of Crambus in the United States and included several new species.

The synonymy of Crambus vulgivagellus Clem. has been listed by Felt (1894). Ainslie (1922, 1923a) listed the synonymy of Crambus mutabilis Clem. and Crambus hemiochrellus Zeller, respectively. The synonymy Nomophila noctuella D. & S. has been reviewed by Ellis (1925).

Taxonomic references to Acrolophus arizonellus Wlshm. were made by Walsingham (1887) and Dyar (1900).

The orginal description of Stenoma mistrella was made by Busck (1906).

Economic Literature

Injury caused by Crambus on grasslands was first observed by Lintner (1881a) who misidentified the larvae causing the damage and called them Cirphis unipuncta (Haworth), the army worm. He described the habits and nature of injury of typical Crambus larvae. He even remarked upon the strange behavior of the supposed army worm and expressed belief that it would soon leave its cocoons in the ground and assume the typical migratory habits of the true army worm.

A week later, Lintner (1881b) admitted his error of identification and said that C. V. Riley had recognized the

larvae as Nephelodes violans Guenee, now a synonym of Nephelodes minians Guenee.

The confusion of names of the larvae causing the damage in the East continued until Lintner (1881c) again corrected his previous errors of identification and correctly named the larvae Crambus vulgivagellus Clem., the "vagabond Crambus."

Riley (1881a), as previously mentioned, mistook the Crambus larvae for Nephelodes violans Guenee. He corrected this mistake (1881b) and indicated that the larvae in question were Crambus vulgivagellus Clem.

This species must have reached outbreak proportions, as Riley (1881c) made the following observations: "On the island on the Roquette River, which has been absolutely denuded of grass, the worms had so thickly congregated under the shade of a solitary oak tree, that its base for about 18 inches was covered with a layer of silken web."

Lintner (1881c) wrote of control measures against the moths as follows: Barrels of water were placed in the fields, with a film of kerosene on them, which was set on fire. The moths were attracted to the lights in vast numbers and killed.

Felt (1894) published the first paper on the bionomics of Crambus. He considered 27 species including Crambus

vulgivagellus Clem.; C. praefectellus Zincken; C. teterrellus Zincken; and C. mutabilis Clem. His work on the life histories of these insects was quite general. Only one specific food plant was mentioned, blue grass for C. teterrellus. The morphological drawings of the adults were particularly valuable.

Fernald (1896) wrote an extensive taxonomic paper on Crambus. He dealt with 55 species and several other genera within the same sub-family. The life histories given in this publication were largely quotations from Felt together with observations made by other early writers.

Ainslie (1916, 1917, 1918, 1922, 1923a, 1923b, 1927, 1930) has contributed much on the bionomics of several species of Crambus. A few of his many publications include papers on Crambus trisectus Walker; C. teterrellus Clem.; C. praefectellus Zincken; C. mutabilis Clem.

Reports by Ainslie (1930), Noble (1932), North and Thompson (1937) tell of Crambus attacking grass, especially lawns. Some references by Felt (1894), Ainslie (1922) have been made of injury to field crops. This injury usually occurred when the crop was planted following a period of pasture or meadow. Some of the recent papers by Stirrett and Arnott (1932) and Arnott (1935) are on outbreaks of Crambus in lawns and golf courses in Canada. Recent control

work by Gilmore and Milan (1937), North and Thompson (1937), and Jewett (1939), indicates the increasing importance of the injury by these pests.

MATERIAL AND METHODS

The methods and materials used in the rearing of the species dealt with in this paper were those most commonly employed in entomological work.

Prepupal cases were kept in tin salve boxes in which the adults emerged. The moths collected at lights were kept in glass vials, and they deposited their eggs loosely in these vials. Larval rearings were attempted in tin salve boxes with moist sand and in potted food plants with screen cages. Overwintering material was kept in large screen wire cages, and in a series of glass lantern cages over food materials.

Observations on the injury to food plants caused by C. vulgivagellus larvae were made by placing the roots of individual plants in a test tube of water, while a celluloid and gauze vial was placed over the top of the foliage. A split tapering cork between the two vials acted as a support for the plant and as a stopper to keep the insects within the celluloid vial.

LIFE HISTORY OF C. VULGIVAGELLUS AND CRAMBUS IN GENERAL

Egg Stage

Description and development of eggs. The eggs of various species of Crambus vary slightly in size and shape. The general features of the group, however, are the same.

Felt (1894) briefly described the eggs of C. vulgivagellus. The eggs of this species (Fig. 1) as observed in

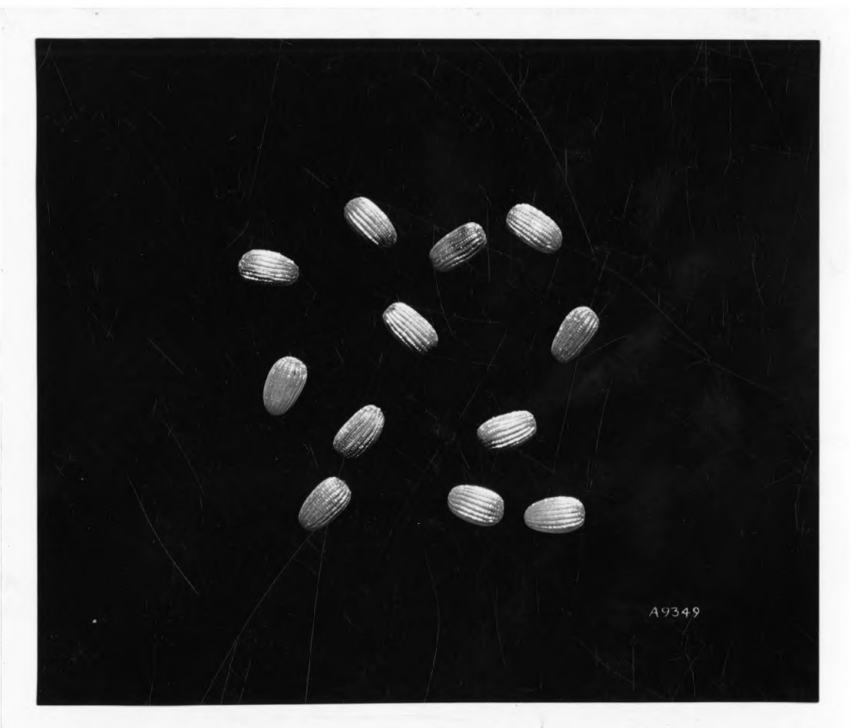


Fig. 1. Eggs of Crambus vulgivagellus

the fall of 1939 were cylindrical with the ends bluntly rounded. One end was often slightly larger than the other.

The chorion had about 20 prominent, rounded longitudinal ridges. In between the ridges were smaller, numerous, transverse carinae. Thus the surface was divided into minute quadrangular depressions. The polar ends were uneven and slightly tuberculate.

The maximum length of 10 eggs was 0.4896 mm., minimum 0.3608 mm., average length 0.4018 mm.; width of the eggs, maximum 0.3624 mm., minimum 0.2424 mm., average width 0.2559 mm.

The eggs were perfectly dry and were not glued to the substratum when laid. One female was observed which laid three eggs while fluttering around in the glass vial.

Fifteen females were put into a screen cage over a clump of crab grass to approximate natural conditions. The majority of the eggs were found on the ground and none were glued to the substratum or arranged in systematic order.

One egg was found in the field. It was caught in the pit of the ligule of the stem of brome grass; apparently this was an accidental find.

Nearly all the 57 females attracted to lights were gravid. All of these except two laid eggs.

Felt (1894) observed the color change in the unhatched eggs. This has been substantiated because the eggs when first laid were pure white, and within an hour they changed

to a light cream color. Then day by day for four days the eggs gradually became first, flesh colored, then light pink, salmon and finally a bright coral red.

As the embryo developed within the egg, the dark head and cervical shield of the larvae could be seen through the egg shell. At first only two tiny, dark spots, they later increased in size until the larvae were fully developed.

During the process of hatching the larvae cut a circular hole in the larger end of the egg. The empty egg shell was nearly transparent and slightly iridescent. The color of the unhatched egg was, therefore, the color caused by the developing embryo. After hatching, sometimes the larvae were not able to free themselves from the egg shell and they dragged it about for a considerable length of time.

Egg laying and hatching records. Fifty-eight moths of C. vulgivagellus (Fig. 2) were used in the rearing experiments. The maximum number of eggs laid by one female was 293; the average number of eggs laid by the 58 moths was 97.896 eggs.

The length of the egg stage was from 10 to 25 days, the average for 5,671 eggs was 16.3 days. Observations of the egg stage were not under optimum conditions. The eggs were first kept in the insectary greenhouse where the temperature became too high during the day time. Apparently

Fig. 2. Female of Crambus vulgivagellus

many fully developed larvae failed to hatch because of the high temperatures.

Larval Stage

Larval instars. The newly hatched larvae had a uniform

pale straw-colored body. The head was a shining black and the cervical shield was slightly lighter in color. Numerous white setae rose from the dorsal and lateral sides of the body. The head was wider than the body. The body tapered in width posteriorly.

Ten newly hatched larvae had a uniform width of the head capsule of 0.117 mm. The average body length was 1.27 mm. Felt (1894) observed "first stage larvae, head diameter 0.19 mm.; body diameter 0.175 mm., length 1.25 mm."

The larvae were active when they came out of the egg shell and seemed to be more interested in a place to hide than in finding food. They were negatively phototropic and soon concealed themselves in the food material. When left in the vial too long after hatching, they webbed the empty egg shells together and concealed themselves within the mass.

Larval injury to food plants. At first the larvae fed by rasping on the epidermis of the leaves. This injury was similar to thrip injury and could be seen only by the aid of a hand lens. As the larvae grew larger, these places became longer and deeper until they were small elongate pits between the longitudinal veins of the leaves. At times a tiny bit of webbing could be seen around the edges of the pits.

As the larvae grew larger they retreated to the base of the plant where they constructed shelter tubes of loosely woven silk.

Rearing of larvae. While attempting to rear the larvae to maturity, a great deal of difficulty has been encountered. At first the limiting factor seemed to be the moisture content of the soil; later the temperature. Experimentation with both of these factors gave no encouraging results. The different kinds of food were also considered as the limiting factor hindering development. Numerous kinds of food were tried and none proved successful for long periods of time.

It was found by placing the food material under wet sand that the larvae would construct shelter tubes, within which they fed and lived for a much longer period of time than otherwise. However, none were reared to maturity by this method.

Each time the shelter tubes made by the larvae were torn open, they would repair them. After this had occurred a few times, they would leave the tubes and migrate to the surface of the soil. Here they stayed and seldom fed, and finally died of some disease.

Attempts at mass rearings of larvae on potted food plants were also unsuccessful. Dead larvae were recovered

Table 1. Injury to food plants by 10-day-old larvae of *Crambus vulgivagellus*.

Kind of food plant	Larvae in each cage	Number of larvae recovered at end of experiment	Type and amount of injury
Brome grass	10	1 alive	One blade of grass slightly skeletonized
Brome grass	10	2 alive	Two places skeletonized on blades of grass
Wheat	10	2 alive	Blades badly skeletonized
Wheat	10	None	No injury
Wheat	10	1 alive	No apparent injury
Wheat	10	1 alive	Few small pits in leaf
Wheat	10	1 alive	Few small pits in leaf
Alfalfa	10	1 alive	Slight rasping around edge of one leaf
Alfalfa	10	1 alive	Rasping more general; slight injury
Crab grass	10	None	No injury
Crab grass	10	3 alive	Plant killed, leaves completely skeletonized

from all of these plants. Apparently none of the larvae had lived more than three or four days. No shelter tubes or injury was found on these plants.

Table 2. Length of life of larvae of Crambus vulgivagellus fed on various food plants.

Food plant	No. larvae used	Max. days alive	Min. days alive	Average days alive
Brome grass	49	20	14	15.0
Indian grass	35	25	12	13.34
Crab grass	25	23	8	13.05
Buffalo grass	26	17	3	12.0
Kentucky blue grass	17	20	5	14.64
Wheat	36	18	2	11.70
Alfalfa	8	14	6	9.0

The three largest of the reared larvae had the following measurements when they died: No. 1 width of head capsule 0.194 mm., length 10.6 mm.; No. 2 width of head capsule 0.17 mm., length 10.4 mm.; No. 3 width of head capsule 0.19 mm., no length measurements were taken.

No data were taken on the larval instars in order that no larvae be sacrificed.

Larvae in the field. Intensive search for C. vulgivagellus larvae in the field has been made. On February 17, 1939, a Crambus larva was found in a clump of false red top grass. No opportunity could be made to study its location in the grass because it was recovered from material being put through the Berlese funnel. This larva was injured and lived for only two days. It was quite small and possibly

in about the third instar. It compared in size with many of the larvae that had been reared nearly to maturity in the fall of 1938.

On April 14, 1939, a C. vulgivagellus larva was found in an overwintering cage on Kentucky blue grass. It was within a loosely woven silken shelter tube which had been constructed around a branch root of the plant. Fecal material had been systematically arranged at one end of the tube. The shelter tube was about twice as long as the larva. The larva was inactive and would not leave the shelter tube. It was old rose in color, with dark brown tubercles and black setae. This larva measured 10.1 mm. in length and its head capsule was 0.15 mm. in width. The plant upon which the larva was found was still alive. This larva died after four days. It had died outside of its shelter tube and had apparently begun to construct another one about itself farther up the plant.

On April 28, 1938, the first larva of Crambus (Fig. 3) was found along the grassy border of an alfalfa field. The larva had constructed a silken shelter tube under a two-inch board. The upper opening of the shelter tube was at the base of a brome grass plant. This larva was active and moved rapidly forward and backward in its shelter tube. The shelter tube was about six times the length of the larva.

Fig. 3. Larva of Crambus vulgivagellus, with shelter tube

Fecal material had again been systematically arranged so that the passageway of the tube was not obstructed. The larva was negatively phototropic. The species of this larva was never determined because it died within 12 days.

Felt (1894) makes the following observations on "larvae late in the fall.--2.5 mm. long. Head jet black; thoracic shield a deep brown; body brown with deep brown

tubercles. The fifth to thirteenth segments inclusive are divided into cephalic and caudal portions by a short transverse constriction."

Overwintering of larvae. An attempt was made to allow C. vulgivagellus to overwinter under approximately natural conditions. During the first week in October, 1938, various types of large and small screen cages and glass lantern cages were put over different food plants. Live moths or eggs or newly hatched larvae were placed in these cages. During May, 1939, the soil and plants in the cages were examined. Only one larva was recovered. This particular larva has been described under the heading of larvae in the field.

Prepupal and Pupal Stages

Location and description of the cocoons. The cocoons of C. vulgivagellus might also be called prepupal cases because the larvae undergo a quiescent stage in these cases before they become pupae. The term cocoon will be used as practiced by previous authors.

The cocoons of C. vulgivagellus (Fig. 4) were located in vertical position in the ground; the upper end was level with the ground or one fourth inch below the surface. Many empty cocoons of some unknown species of Crambus were found

Fig. 4. Cocoons of Crambus vulgivagellus in the soil

this spring projecting from the top of the ground about one fourth inch. It is thought, however, that the soil in this case had eroded away and left the cocoons exposed.

The outside walls of the cocoons were covered with earth which was firmly interwoven with the silk. They were difficult to distinguish from the surrounding medium and could usually be located more readily by the sense of touch than by sight. A fibrous plug was located at the anterior end, which was nearly level with the surface of the soil. This plug was more loosely arranged than the walls of the cocoon and consisted of coarser silk. When emerging, the adults apparently pushed this plug out and escaped. The empty pupal skins were always left within the cocoons.

The inner surface of the cocoons was a dark grey color with a smooth, silken lining. The maximum length of 61 cocoons of C. vulgivagellus was 25.0 mm.; the minimum was 15.0 mm.; the average was 20.06 mm. The width through the thickest part was: maximum 0.8 mm., minimum 0.3 mm., average 0.56 mm.

The first cocoons of C. vulgivagellus were found beside clumps of Andropogon in an alfalfa field. They were located in bare places between clumps and it is possible that the larvae killed the grass in which they were located. No in-

jury was noted to the surviving clumps of Andropogon. The empty cocoons of unknown species of Crambus were located beside the same kind of grass.

The Crambus larvae found within the cocoons were aestivating in the last instar. The shrunken larvae were about one half of their normal size. One of these shrunken larvae measured 0.6 mm. in length. When these larvae were taken out of these cocoons they lengthened out and assumed their normal size, but they were never active. None of the larvae fed while within these cocoons. The larvae repaired the cocoons only a few times after they were torn open, then

Table 3. Number and location of cocoons of Crambus vulgivagellus in the field.

Station number	Number of cocoons	Type of large grass present	Location in the field or types of small grass
1	3	Andropogon	Located in the grassy part of an alfalfa field
2	9	Andropogon	Some small bunches of Japanese chess or Brome tectorum present along the border of area
3	6	Andropogon	Few bunches of Japanese chess along edges of area
4	5	Andropogon	No data
5	5	Andropogon	No data
6	46	Andropogon	Five alfalfa plants all within one foot of the Andropogon

they would come to the surface and make no further attempt to construct cocoons nor to eat. Afterwards the larvae invariably died of either bacterial or fungus disease.

Fifteen prepupal cases were placed in the ice box of alfalfa research greenhouse. They were subjected to a temperature of 30 degrees F. for two weeks. Ten of the larvae on examination were dead. Five had formed pupa. One pupa contained a dead parasite. Another pupa had died. Three adults emerged at normal time and apparently were not affected by the cold shock.

Three cocoons were kept in Insectary No. 2 cave for overwintering observations. They were examined on May 5, 1939. Two dead adults were found within their pupa. One dead larva was also found within the cocoon. The other cocoons used in connection with this experiment were destroyed by mice or were found to be empty.

Description and length of pupal stage. The length of five pupa of C. vulgivagellus varied from 9.9 mm. to 10.8 mm., average, 10.2 mm.; width, from 2.6 mm. to 3.0 mm., average, 2.8 mm.

The pupa of C. vulgivagellus was light brown in color. Spiracles were present on abdominal segments three to nine, respectively. On abdominal segments three and four they were located along the edge of the wing cover. The spiracle

on the ninth abdominal segment was merely a scar. The cremaster was a rounded process flattened dorsally. On its edge were two widely separated minute setae. Closer to the tip along the edge of the cremaster were two more minute setae. The anal opening and the genital opening were on the median line. The anal opening had two individual, slightly rounded processes on each side.

The pupal period for 17 pupae varied from 8 to 21 days, the average being 13.88 days. The empty pupal skins were always found in the cocoon after the adult had emerged.

Adults

Description of C. vulgivagellus and Crambus in general. Crambus moths can be distinguished from other moths in the field by the fact that they wrap their wings tightly about their abdomen when resting. They will also fly for only a short distance and then alight head downward on a stem of grass. Their flight is irregular and spasmodic. Their long labial palpi are diagnostic for field identification.

Moths of C. vulgivagellus (Fig. 2) have a wing spread of about 20.5 mm. The forewings are clay colored, flecked with black. Darker longitudinal markings follow the wing venation. The ventral border of the forewings have a row of terminal black dots and silver colored fringe. The hind

wings are yellowish, with the fringe slightly lighter in color. The labial palpi are long, densely scaled, clay colored flecked with black, with a tiny tip of silver. The antennae are long and are carried dorsally over the thorax. The shape of the segments differs with the sex of the moth, the males having the larger segments.

The conical frons is distinctly different from closely related Crambus species. It extends anteriorly nearly the width of the head (Figs. 5 and 6). The ocelli which are located on the top of a stubby, black stalk are posterior to the antennae and near the compound eyes.

Male genitalia of C. vulgivagellus. Felt (1894) figured the male genitalia of the C. vulgivagellus but did not describe it. The tegumen is right angled and elbow shaped. The base is split into two branches which are attached to the dorsal end of the saccus (Figs. 7 and 8). The main trunk of the tegumen is cylindrical, the dorsal half sclerotized and the ventral half membranous. A tuft of long setae arises on the lateral surface of the branches of the tegumen quite close to the point of attachment to the saccus.

The uncus is solidly attached to the tegumen and tapered to a point. The tip is directed ventrally. Short setae, inclined cephalad, cover its entire surface.

The socius is two branched at the dorsal end. The two

Explanation of Plate I

Fig. 5. Dorsal view of head of adult *Crambus vulgivagellus*.

Fig. 6. Lateral view of head of adult *Crambus vulgivagellus*.

Fig. 7. Lateral view of male genitalia of *Crambus vulgivagellus*. (Labeling according to A. B. Klots in de la Torre-Buena (1937). p. 332-334.

Fig. 8. Dorsal view of male genitalia of *Crambus vulgivagellus*.

Plate I

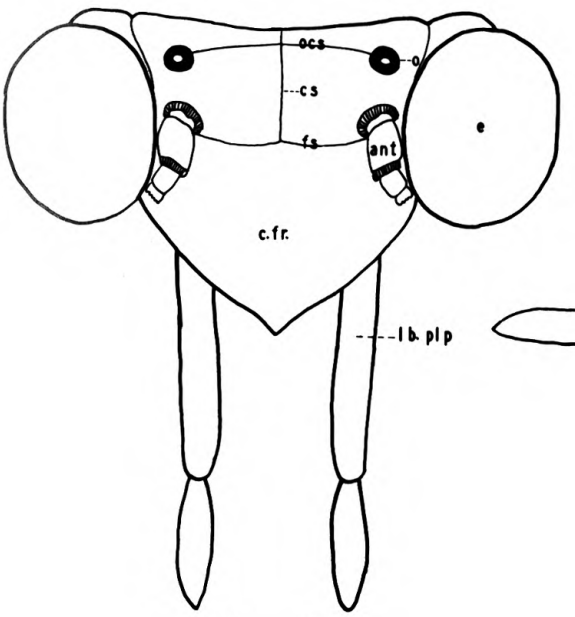
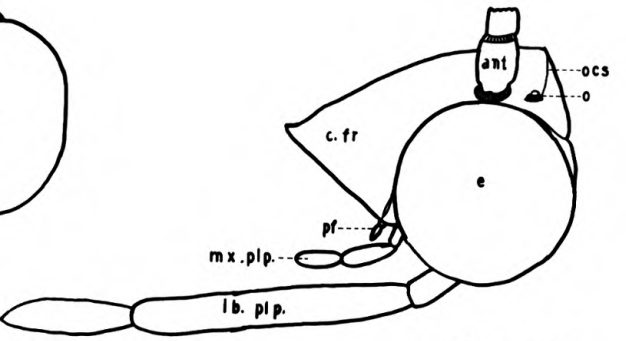


Fig. 5.



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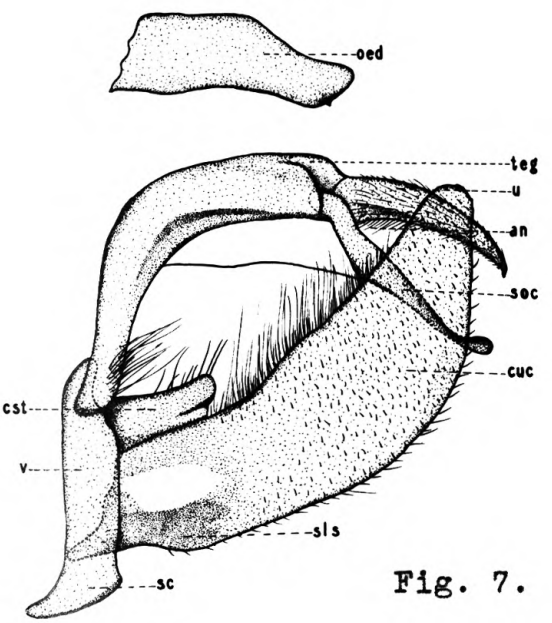

Fig. 7.

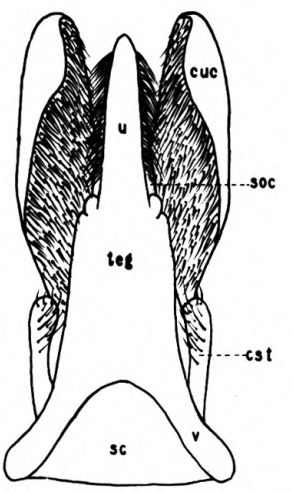

Fig. 8.

ends are inserted into slits at the end of the tegumen which apparently forms a movable hinge joint. The ventral membranous portion of the tegumen attaches to the cephalic surface of these two branches. The main trunk of the socius is slender, with a slightly enlarged tip.

The tip of the cucullus is on a level with the base of the uncus and obscured most of the uncus and socius in the lateral vein. It is somewhat wider in the middle than at the base. The lateral surface of the cucullus is nearly covered with short, fine setae. It is sclerotized except for a small area at the center of the cucullus near the border which attached to the vinculum.

The medial surfaces are densely covered with long, white setae. The costa of the cucullus which is rounded dorsally bears a few medium sized setae.

The oedeagus bears a short sclerotized spine on the ventral caudal surface.

The last segment of the abdomen apparently attached in the region of the ventral portions of the vinculum and the branches of the tegumen. Only the tips of the uncus and socius can be seen, so that the last abdominal segment must be dissected away to expose the genital structures. Tendon-like structures have been observed in the region of attach-

ment, and they probably aid to eject the genitalia during copulation.

Wide variation in the structure of the tegumen, socius and cucullus have been observed in the various species of Crambus.

Male genitalia of C. leachellus is covered with a crown of densely matted, long, white setae which completely conceals the genital structure.

Adults in the field. During the latter part of September and first part of October the adults of C. vulgivagellus were abundant in alfalfa and grass crops. They seemed to prefer the grasses to other forage crops. The moths in the field were never observed feeding nor were they attracted to flowers present.

On September 24, 1938, sweeps were made on alfalfa and grasses. A total of 49 moths was collected. Of these, 23 were males and 26 females.

Table 4. Number and sex of moths of Crambus vulgivagellus in relation to humidity and temperature.

Date	Time	Place	Temp.	Humidity	Males	Females
Sept.25:	7:30 p.m.	City park:	78° F.:	39%	1	29
Sept.25:	8:00 p.m.	Eng.Bldg.:	79° F.:	37%	2	41
Sept.25:	9:00 p.m.	Eng.Bldg.:	79° F.:	39%	8	65
Sept.25:	10:00 p.m.	Eng.Bldg.:	78° F.:	39%	9	84
Sept.25:	11:00 p.m.	Eng.Bldg.:	75° F.:	42%	12	61
Sept.25:	12:00 p.m.	Eng.Bldg.:	71° F.:	44%	12	69

One pair was found copulating in the morning under cover of a heavy growth of brome grass.

Adults at lights. From the middle of September to the second week in October the adults were abundant at lights. On some nights their numbers were so great that they were a pest at store fronts and street lights. Approximately 3,000 moths were caught in one night at the college light trap. The females usually came to the lights in the fore part of the evening and the males toward morning. In the above table the moths were all at lights and were collected at random.

The material used in the following table was obtained

Table 5. Relation of sexes of moths of Crambus vulgivagellus to time, temperature, and humidity.

Date	Time	Temperature (at 12 p.m.)	Humidity (at 12 p.m.)	Males	Females
Sept.27	7 p.m.till 12 p.m.	63° F.	30%	152	64
Sept.27	12 p.m.till 4 a.m.			960	96
Sept.28	7 p.m.till 12 p.m.	65° F.	41%	29	43
Sept.28	12 p.m.till 4 a.m.			668	302
Sept.29	7 p.m.till 12 p.m.	68° F.	40%	162	520
Sept.29	12 p.m.till 4 a.m.			1264	448
Sept.30	7 p.m.till 12 p.m.	68° F.	31%	48	192
Sept.30	12 p.m.till 4 a.m.			376	128

from the Entomology department light trap. The figures represented are an estimate of the total because only one eighth of each catch was counted. The figures for September

28, however, is an accurate count of total moths present. An error of 0.7 per cent may be assumed on total amounts for the estimated groups.

Longevity of adults. Females of C. vulgivagellus lived a maximum of seven days, after having been collected at lights, 58 of which lived an average of 1.241 days. Nine males were collected; three of these lived for five days, their average life being 3.08 days.

An attempt was made to keep adults alive longer in the laboratory by feeding them water or diluted sugar solution. No apparent difference in the length of life could be observed.

LIFE HISTORY OF C. MUTABILIS CLEM.

Moths of C. mutabilis were taken in bluestem pastures in June, 1939. Their flight was typical of the Crambus moths in general and they alighted on grass stems head downward. None were observed feeding. They preferred grasses to other crops available.

The color of the moth is a brownish grey with a dark brown bar on the costal margin of the forewing. This bar fades toward the ventral portion of the wing. A dusky dark spot is present near the center of the wing, and the ventral

third of the forewing is darker. The hind wings are grey with the fringe slightly lighter. The labial palpi are approximately 2 mm. in length and brownish grey in color. The females are slightly larger. The antennal segments are noticeably different in the sexes. In the antennae of the male the segments are broader and have a deep notch at each joint while in the female the segments are slender and lack the notch. Ocelli are present behind the antennae and close to the compound eyes.

One female collected at lights laid 180 eggs. Ainslie (1923) reported 500 eggs laid by one female. The eggs were loosely laid in the vial. When first deposited they were pure white, then cream and in three days light pink. Ainslie (1923) stated that the color changed from pale cream to pale salmon yellow within a period of three days.

The length of 10 eggs from the same female varied from 0.475 mm. to 0.55 mm., average, 0.512 mm.; width, from 0.30 mm. to 0.375 mm., average, 0.337 mm. Ainslie (1923) observed that the size of the eggs was not constant with different females. His measurements were "length, 0.441 mm. to 0.494 mm., average, 0.479 mm.; width, 0.265 mm. to 0.318 mm., average, 0.306 mm."

The eggs were elliptical in shape, with both ends slightly flattened. The chorion had 18 prominent longitu-

dinal ribs with numerous minute, transverse carinae between the ribs. Ainslie (1923) indicated that the number varied from 16 to 20, the usual number being 17. The polar ends of eggs were tuberculate.

As the embryo developed within the eggs, the typical dark spots of the developing head and cervical shield of the Crambus larvae appeared. The larvae hatched in seven days. Ainslie (1923) reported that the eggs hatch in five to seven days.

The newly hatched larvae had a jet black head, the cervical shield was lighter in color. The abdomen was faintly straw yellow, which confirms Ainslie's description of the first instar. The average width of 10 larval head capsules was 0.15 mm. Ainslie (1923) indicated the width of eight head capsules was 0.194 mm.

The larvae fed gregariously on brome grass in a tin salve box with plaster of Paris bottom.

Ainslie (1923) observed seven instars in the larvae. He reared the larvae on blue grass and noted that in about the fifth instar they constructed cocoons in the ground. This occurred about the last of September and provided winter quarters for the larvae. They began feeding again in April and the moths emerged about the middle of May. Larvae

were taken on blue grass, corn, wheat, timothy and were also reared on crab grass, barley and rye. Three generations a year were reported for Tennessee.

LIFE HISTORY OF C. HEMIOCHRELLUS ZELLER

The moths of this species were collected at lights in June, 1939. The size and color of the moths are similar to C. mutabilis. The forewings have the same dark bars along the costal margin; however, the dark spot in the center of the wing is replaced by a faint white V-shaped bar. The point of the V is directed toward the attachment of the wing. The dorsal line of the V fades at about the center of the wing while the ventral line extends to the margin of the wing.

One of the females collected at lights laid 244 eggs. Ainslie (1918) observed that one female laid 303 eggs. Differences of size and color between the eggs of the two species were noted. The eggs of C. hemiochrellus were more elongate and larger. Sixteen or 17 longitudinal ribs were present and the apex of the ribs of the eggs of this species were wider and flatter than was the case of C. mutabilis.

The color of the eggs when first deposited was white, turning to cream and within three days to faint flesh

color, which color they retained until they hatched. Ainslie (1923) stated "the eggs of the two assume and retain exactly the same color during the incubation period." But he (1918) also stated "during their incubation period the eggs of the two species assume very nearly the same shade, a pale salmon-yellow."

The measurements of 10 eggs were from 0.550 mm. to 0.585 mm. in length, the average, 0.561 mm.; width, from 0.300 mm. to 0.395 mm., average, 0.334 mm. Ainslie (1918) gave the measurement of 10 eggs as: "length, maximum 0.529 mm., minimum 0.460 mm., average 0.496 mm.; width, maximum 0.318 mm., minimum 0.300 mm., average 0.307 mm.

The eggs showed characteristic dark spots through the egg shell while developing. This confirms the observation of Ainslie (1918).

The larvae hatched within 10 days. Ainslie (1918) recorded a maximum of nine days for hatching. The average width of the head capsule of 10 larvae was 0.15 mm. Ainslie (1918) observed an average of 0.194 mm. He also listed the range of larval instars varying from 8 to 10, the greater number having an average of 8 instars. The pupal period had an average of 10.4 days. He reared the larvae to maturity on blue grass, but stated that nothing was known as to their normal food plants.

The larvae in this study have been reared on brome grass but the mortality rate has been high. The same type of rearing procedure has been used as in the case of C. mutabilis.

CONTROL OF CRAMBUS

Natural Control

Parasites and predators. The following larval parasites of C. vulgivagellus have been reported: Felt (1894), Lampronata frigida Cress, Cryptus mundus Prov., Perilampis violaceous Dalm. Fernald (1896) reported the only recorded predator: Calosoma calidum (Fab.).

Ten species of Lissonata frigida (Cress), Ichneumonidae, were reared from the prepupal case of C. vulgivagellus. These specimens were identified by R. A. Cushman of the Bureau of Entomology. These parasites made cocoons within the prepupal cases of C. vulgivagellus. The parasitic pupal case was light brown and approximately 10 mm. long and 0.3 mm. wide. The parasite emerged about the same time as the C. vulgivagellus adults. The empty pupal skins were always left within the cocoons of the host.

Bittacus occidentis Walker was observed capturing adults of Crambus at lights. These specimens were identi-

fied by Dr. Roger C. Smith. They were quite numerous at lights and seemed to prefer Crambus to other insects present. One specimen of B. occidentis killed three Crambus adults in a period of about 20 minutes.

Ainslie (1923) observed the following parasites on C. mutabilis Clem.: Phoraocera claripennis Macq., Exorista nigripalpis Towns., Apanteles crambi Weed., Macrocentrus crambiriorus Vier.

Noble (1932) reported Phoraocera claripennis Macq. and Zenillia caesar Ald. as larval parasites of Crambus spp. He also observed the following birds as larval predators: Blackbirds, flickers, robins, starlings. In addition to the above predator birds, Stirrett and Arnott (1932) observed grackles, crows and killdeers preying upon Crambus larvae.

Artificial Control

Cultural methods. Felt (1894), Headlee (1915), Ainslie (1923) and many others have indicated that injury to corn and other cultivated crops by Crambus usually occurs when this crop follows grass or pasture. Felt (1894) recommended burning and rolling of the ground in limited areas, which would destroy the shelter tubes. Ainslie

(1922) suggested that by early fall plowing the larvae were disturbed and their food destroyed. This forced them to go into the winter in a starved or poorly protected condition. He also advised that when a field of young corn became infested to replant the field, putting the new rows midway between the old infested rows. By leaving the infested plants standing undisturbed, the new plant will grow without infestation. He said that good seed, thorough preparation of the seed bed and application of fertilizer would aid the plants and materially lessen injury.

The use of standard farm machinery such as the disc, springtooth harrow and lister would reduce the infestation by destroying the shelter tubes and causing injury to the larvae.

Insecticides. Noble (1932) found that two commercial pyrethrum extracts or kerosene emulsion were effective on sod infested by Crambus larvae. The commercial pyrethrum extracts were diluted one ounce to four gallons of water. One gallon of solution was applied to one square yard of surface. All larvae came to the surface a few minutes after the application. Some of the larvae lived for several hours but eventually died. No injury was caused to the grass. The kerosene emulsion was made of one pound of laundry soap, one gallon of water, and one half gallon of

kerosene. One gallon of emulsion was added to 50 gallons of water and applied at the rate of one gallon diluted emulsion to one square yard of infested sod. Again the larvae came to the surface and wriggled about until they died. No apparent injury resulted to the grass.

North and Thompson (1937) recommended lead arsenate, 2 pounds to 20 gallons of water, applied to 1,000 square feet as a control for webworms in the turf.

Campbell and Stone (1937) recommended the use of dichloroethyl ether to control Crambus larvae. This was diluted at the rate of one gallon to one square yard of infested sod. These authors obtained 100 per cent kill to the Crambus larvae and the grass showed no perceptible injury after treatment.

Gilmore and Milan (1937) recommended use of poison bait flavored with nitrobenzene to control C. caliginoselus Clem., the corn root webworm, causing injury to tobacco. The poison bait was made of Paris green 1 pound, corn meal 25 pounds, nitrobenzene (oil of mirbane) 1 ounce. Best results were obtained when 15 to 20 pounds were used per acre. This material was sifted upon the tobacco plants immediately after they were transplanted to the field.

Jewett (1939) obtained the best results in controlling Crambus larvae by use of three insecticides: pyrethrum ex-

tract, kerosene emulsion and lead arsenate. The pyrethrum extract contained two grams of pyrethrins in 100 c. c. and was diluted one ounce to four gallons of water. Two gallons of the solution were used to treat 20 square feet. This treatment was 96.1 per cent effective. The kerosene emulsion consisted of one and a half pounds hard soap, one gallon of water and two gallons of kerosene. A dilution of 1 part to 10 parts of water was applied, at the rate of 2 gallons to 20 square feet. This was 93.2 per cent effective. No injury to grass resulted so long as proper mixtures were used. Lead arsenate used as a powder applied at the rate of three fourths pound on 100 square feet of sod was 71.9 per cent effective. Lead arsenate 2 pounds in 20 gallons of water was 92.5 per cent effective, when applied at the rate of two and a half pounds to 1,000 square feet. The other insecticides tried were dichloroethyl ether, barium carbonate, nicotine oleate, derris, "loro," "lethane, jr.," and poison bait. The dichloroethyl ether applied at the rate of one gallon on one square yard as recommended by Campbell and Stone (1937) was 42.8 per cent to 74.0 per cent effective. The rest of the insecticides gave practically no control.

No opportunity presented itself to conduct control measures against Crambus larvae at Manhattan.

CLOSELY RELATED FORMS OF CRAMBUS

Life History of Nomophila noctuella D. & S.

Adults of this species were somewhat similar to Crambus. They were about the same size and rubbed specimens had the same coloration. In the field, their flight was also erratic and they would alight usually near the base of the plant, concealing themselves quickly under the blades of grass. They were found in grasslands and alfalfa fields.

The moths (Fig. 9) are somewhat larger than Crambus and the labial palpi are short. They have a wing spread of about an inch. The forewings are light brown with three chocolate brown, transverse bands. The ventral border of the forewing has a serrate, transverse, narrow black bar. Two lighter and still narrower transverse bars are present on the fringe. The wings when at rest are usually held transversely over the abdomen and the ventral portions of the wings sometimes overlap one another.

The adults have never been observed feeding nor are they attracted to flowers in the fields. They were largely day fliers but were attracted to lights.

The eggs of N. noctuella (Fig. 10) were glued singly and irregularly to the substratum. They were light green

Fig. 9. Adult of Nomophila noctuella

in color when first deposited and soon changed to light brown. The eggs were oblong ovate, flattened ventrally. The chorion was covered with a fine mesh-like network and was highly iridescent. This in general confirms the observations made by Ellis (1925)

Flint (1922) observed females which laid over 100 eggs.

"The average egg period was six days, average larval period thirty days, average pupal period ten days."

Felt (1893) noted that the larvae fed mainly on legumes. According to Flint's (1922) observations, "the lar-

Fig. 10. Eggs of Nomophila noctuella glued to brome grass leaf

vae seemed to prefer red clover, sweet clover, and alfalfa." He also noted that "they have been found in a few cases

feeding on blue grass, purslane, corn, wild mustard, cinquefoil, white clover, foxtail and in one instance soybeans." Ellis (1925) and Hutson (1934) reported the insect doing damage to celery.

The larvae have been described by Felt (1893) and Flint (1922). According to Ellis (1925), the larvae were dirty white to pale green, depending on what they had eaten. The head capsule and cervical shield were chestnut brown. Full grown larvae measure 0.81 inches in length. Unusually long setae rose from the pinacula on the segments of the body.

One larva of N. noctuella (Fig. 11) was found during these studies in an alfalfa field. No shelter tube was present; however, the larvae had just completed moulting. In the laboratory, the larvae constructed silken shelter tubes which encircled the bottom of the petri dish. The larvae pupated and 14 days later an adult N. noctuella emerged.

Flint (1922) observed that "they fed in much the same manner as Crambid larvae, making a shallow burrow in the ground, loosely lined with silk, and a silken tube extending a short distance from this burrow. The first instar larvae feed mainly on the under sides of leaves, especially where such leaves come in contact with the ground. They work as skeletonizers, leaving the coarser parts of the leaves.

After the third instar the larvae work on both the upper and under sides, and eventually consume the entire leaf, unless the veins are large and very woody. Frequently the stalk of small plants and the stems of the leaves are cut off close to the ground and the leaf or plant dragged to the burrow and then nearly all consumed. The larvae also frequently web the leaves lightly together when feeding upon them."

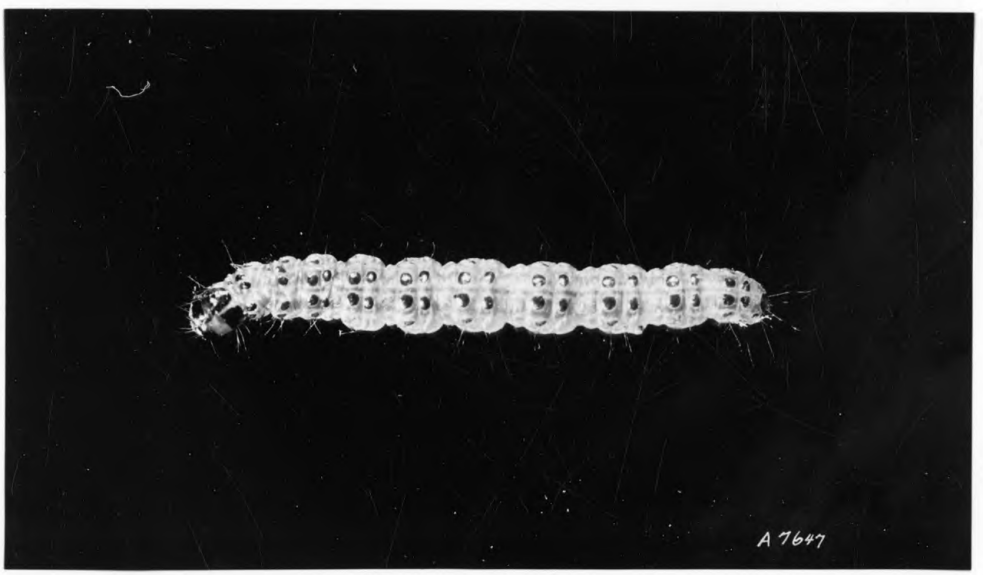

Fig. 11. Mature Nomophila noctuella larva

The pupa (Fig. 12) observed in the laboratory was within the larval shelter tube. The wing cover and thorax were reddish brown in color, while the abdomen remained yellowish brown. The pupal period was 14 days long.

Fig. 12. Pupa of Nomophila noctuella

Life History of *Acrolophus* sp.

The *Acrolpphus* spp. of Kansas, of which *A. arizonellus* Wlshm. appears to be the commonest species in collections, were first observed at lights the last of May, 1939. On June 2, 1939, 521 moths were collected during the night at the entomology light trap.

Fig. 13. Female *Acrolophus* sp.

The moths have a wing spread varying from 22 mm. to 34 mm. The females (Fig. 13) are predominantly larger. The labial palpi of the female are porrect and relatively short in comparison to the male. The appearance of the labial palpi of the females causes them to be easily confused with Crambus. The male labial palpi are much longer and upturned over the vertex and thorax. The wing coloration varies from light brown with dark areas on the forewings to a uniform brownish black. Some other specimens, presumably another species, have a reddish brown coloration of the wings. The wings of all of the Acrolophus spp. are held roof-like over the abdomen when moth is at rest.

The majority of the females collected at lights were gravid. They deposited their eggs loosely in glass vials. When first laid they were white in color and changed to brownish black within one day. This color they retained until hatching. Unfertilized eggs changed from white to a straw yellow. One unfertilized female collected at lights deposited 1,017 eggs. Among the fertilized females also collected at lights, the maximum number of eggs obtained from one female was 327. Seven females deposited an average of 147.3 eggs each.

The eggs (Fig. 14) resembled the Crambus in shape.

They were elliptical and the chorion had from 26 to 29 longitudinal ribs. Twenty-six of these ribs usually extended from end to end of the egg; the others were short ribs present only at the ends. Numerous minute transverse cari-

Fig. 14. Eggs of Acrolophus sp.

nae were also present between the longitudinal ribs. The polar ends of the eggs were tuberculated. Five eggs had a

uniform length of 0.295 mm. The width varied from 0.270 mm. to 0.278 mm., with an average of 0.271 mm.

The larvae during the process of hatching cut an irregular circular hole in one end of the egg. The color of the empty egg shell remained brownish black. The newly hatched larvae were pale yellow with greyish brown head capsule. The occipital suture was deeply indented. Dark ocelli could be seen forming a semicircle. Slender white setae arose from the body. The body tapered in width from behind the head posteriorly. The width of the head capsule of 10 larvae was uniformly 0.300 mm. The head capsule was longer than it was wide. The length of the body varied from 1.25 mm. to 1.55 mm., average, 1.395 mm. Acrolophus larvae were not as active as newly hatched Crambus larvae.

Rearing experiments of Acrolophus larvae were first conducted in tin salve boxes with plaster of Paris bottoms. The food materials used were brome grass, bluestem, Kentucky blue grass and alfalfa. In each salve box fine chippings of roots were also placed. None of the larvae fed or lived in these cultures. The larvae are now being reared gregariously in tin salve boxes with moist organic soil which contains fine root chippings. Apparently only slight changes of the larvae have occurred since the time of hatching. One larva was observed to have constructed a small

silken tube about itself. This larva, however, died in a few days.

One nearly mature larva (Fig. 15) was found in a pas-

Fig. 15. Mature Acrolophus sp. larva

ture under a clump of big bluestem grass. No shelter tube or webbing of any kind was found with it.

The larva was long and slender, resembling a wireworm in shape. The head capsule and cervical shield were dark brown. The head capsule except for the clypeus and frons was pitted. The larger portion of the head capsule was retracted under the cervical shield. The skin between the head capsule and cervical shield was membranous and resembled crocodile skin in texture. The abdomen was velvety brown in color. Slender setae (Fig. 18) arose from small

pinacula on the abdomen. A large brown pinaculum covered most of the dorsal surface of the tenth segment. One of the distinguishing characters used in the identification of Acrolophus larvae by Fracker (1915) was the multiserial cir-

Fig. 16. Pupa of Acrolophus sp.

cle of crockets. This type of crockets (Fig. 21) was present on the four pairs of prolegs and also on the prolegs of the last abdominal segment. The width of the head capsule

(Fig. 19) of this larva was 2.60 mm. and the length 29.0 mm.

The pupae (Fig. 16) were light brown in color. Each segment of the abdomen had a wide, elevated ridge; the dorsal edge of this ridge bore a row of spines. This row of spines was present on abdominal segments three to nine, respectively. The forks of the cremaster were short.

Empty pupal skins could be found in the fields sticking up about three fourths of their length from the silken tubes or they would be lying on the ground, and near by the empty silken tubes could be found.

The silken tubes (Fig. 17) were in a vertical position in the ground; they varied in length and width. The largest found was approximately three inches long and one half inch wide. No earth adhered to the outside of the tubes and they were white in color. The walls were composed of thin but tough silk. At the bottom of the tubes could be found the last larval skins and head capsules.

As many as 10 of the Acrolophus tubes were found per square foot, in a pasture composed mainly of big and little bluestem. They were also found in large numbers in pure stands of brome grass, Panicum and alfalfa. In all of the pastures examined around Manhattan, Acrolophus tubes and empty pupal skins were found. In one case Acrolophus tubes

and Crambus cocoons were in the same area, within one inch of each other. Apparently the larvae of both of these species had fed on the same food plant.

Fig. 17. Silken tube and empty pupal skin of Acrolophus sp. in the soil

Adults have never been taken in sweeps nor have they been seen flying during the day time. However, while in-

Explanation of Plate II

Fig. 18. Setal map of *Acrolophus* sp. larva.

Fig. 19. Cephalic view of larval head capsule of *Acrolophus* sp.

Fig. 20. Lateral view of tarsus and pretarsus segment of *Acrolophus* sp. larva (note pretarsal angle and shape of thumb).

Fig. 21. Crotchet of *Acrolophus* sp. larva.

Plate II

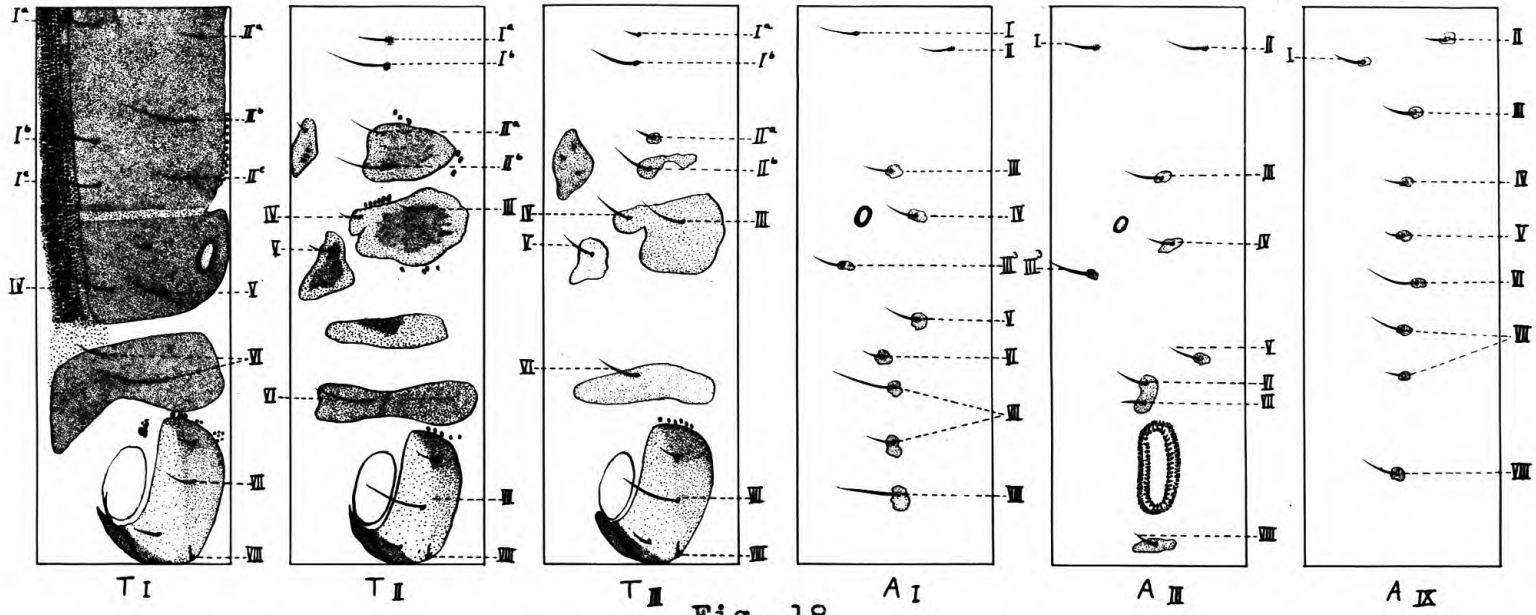

Fig. 18.

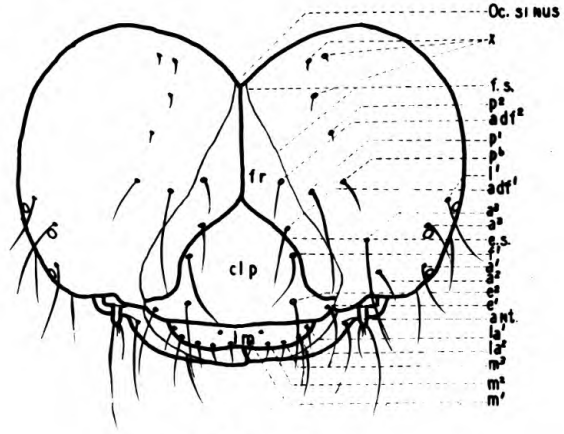

Fig. 19.

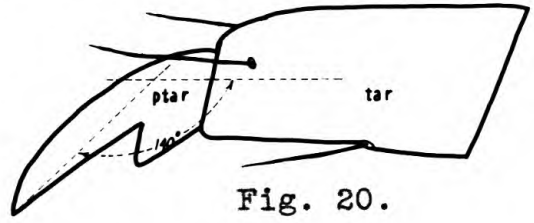

Fig. 20.

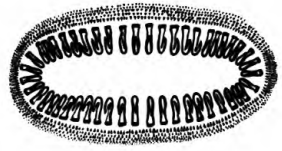

Fig. 21.

tensely searching on hands and knees, two females and one male have been taken. These were easily captured with the hands and they made no attempt to fly but crawled over the hands. When released and put on the ground they took shelter under the plants. As has been indicated before the moths were attracted to lights at night.

While making collections at lights six pairs have been observed in the act of copulation. Their attachment appeared to be firm, as they could be subjected to rough treatment before the union was released.

One tachnid parasite, Distichona varia vd Wulp. was reared from an Acrolophus silken tube containing the dead body of a larva. Apparently this is a new parasite record. The tube was found in its usual upright position. The body of the dead larva was at the bottom of the tube. The puparum of the parasite was within the dead larval body.

Life History of Stenoma mistrella Busck

The larvae of Stenoma mistrella were found on a pure stand of brome grass at the Agronomy farm. They were pinkish brown in color with chestnut brown head capsule and black cervical shield. A dark longitudinal stripe was found on the dorsal median surface of the abdomen. Two light stripes were parallel to this on either side. The head cap-

Explanation of Plate III

Fig. 22. Setal map of Stenoma mistrella.

Fig. 23. Cephalic view of larval head capsule of Stenoma mistrella.

Fig. 24. Lateral view of tarsus and pretarsus segment of Stenoma mistrella larva (note pretarsal angle and shape of thumb).

Fig. 25. Crotchet of Stenoma mistrella larva.

Plate III

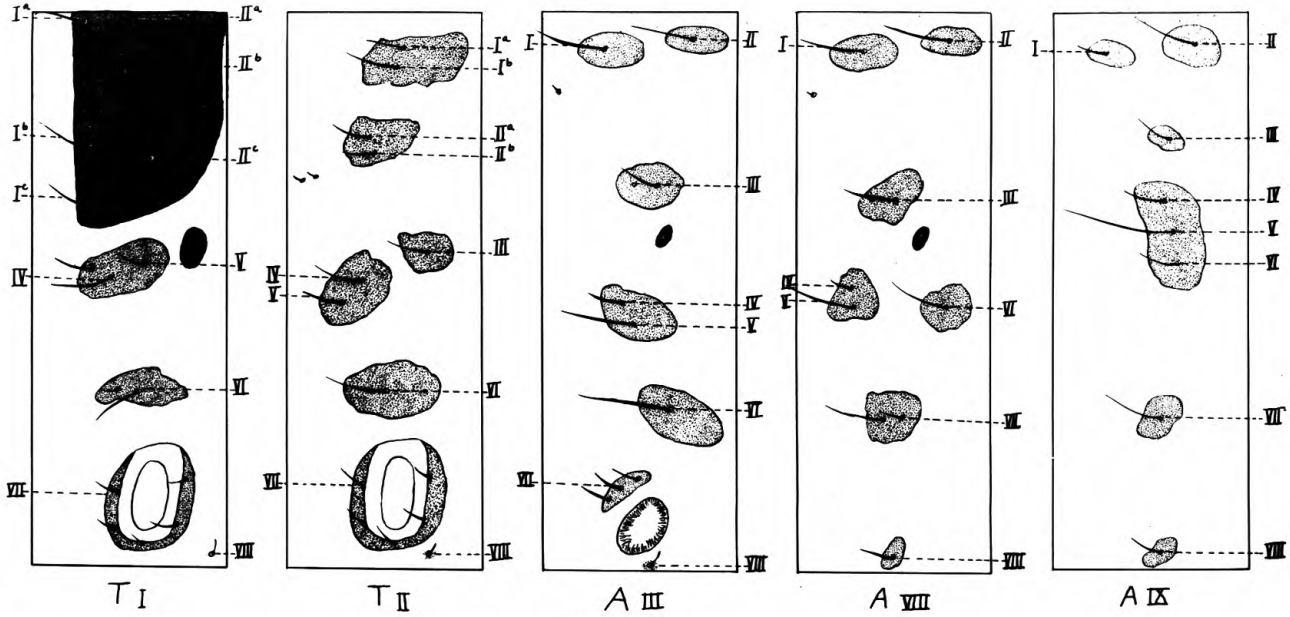

Fig. 22.

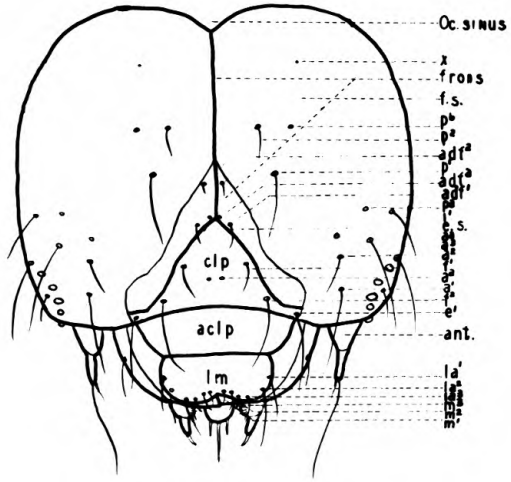

Fig. 23.

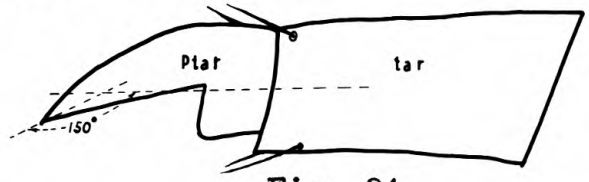

Fig. 24.

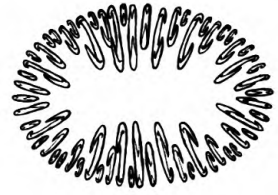

Fig. 25.

sules of the seven larvae collected varied greatly in size; apparently they were in several different instars. Their measurements ranged from 1.1 mm. to 2.0 mm. The same type of Crambid crotchets (Fig. 25) was present on the four abdominal prolegs and the proleg of the last abdominal segment. The larval setal pattern (Fig. 22) resembled that of Nomophila noctuella and when the larvae were first collected, they were tentatively misidentified as Nomophila larvae.

The shelter tubes of these larvae were similar to that of Crambus larvae. They were constructed at the base of the plant and usually followed the stem of the plant to the ground. Some blades of grass were incorporated in the sides of the tubes. These tubes were difficult to find and small pieces of webbing were usually first seen. Pale green fecal matter was also present. None of the larvae were found below the surface of the ground. The larvae were active in their movements and would move either forward or backward rapidly. They were negatively phototropic.

June 3, 1939, the first larvae pupated. The pupa was light brown in color at first and turned to olive brown. The cremaster was bluntly pointed. Four setae of equal length were on the edges of the cremaster. The anal slit was long compared to the other species and the genital pore small. The spiracles appeared to be scars. The region of

the eyes appeared to be ridged. Two pupae both measured 7.0 mm. in length and 2.5 mm. in width. They emerged in six days.

The adults were uniformly light grey in color. Slender labial palpi extended over the vertex. The wings were held in a roof-like manner over the abdomen. In appearance they resembled somewhat the Acrolophus.

MORPHOLOGICAL STUDIES

Larval Characters of the Various Species

Differences in size and shape of the mandibles were noted. The Acrolophus larvae (Fig. 19) had strong, wedge-shaped mandibles with broad cutting edges. They resembled those of grub worms and suggested that the larvae had root feeding habits. The Stenoma mistrella larvae (Fig. 23) also had quite heavy mandibles, which would suggest similar habits. The Crambus larvae (Fig. 31) mandibles were much lighter in structure and the tips were pointed.

The crotchets of C. vulgivagellus (Fig. 29) and Stenoma mistrella (Fig. 25) appear to be identical.

The setal pattern of these species (Figs. 18, 22, and 26) were numbered according to Heinrich (1919). Ellis (1925) has figured the larval setal map of Nomophila noctu-

Explanation of Plate IV

Fig. 26. Setal map of *Crambus vulgivagellus* larva.

Fig. 27. Dorsal view of larva of *Crambus vulgivagellus*.

Fig. 28. Lateral view of tarsus and pretarsus segment of *Crambus vulgivagellus* larva (note pretarsal angle and shape of thumb).

Fig. 29. Crotchet of *Crambus vulgivagellus* larva.

Fig. 30. Lateral view of tenth abdominal segment of *Crambus vulgivagellus* larva (note setal pattern and sclerotization).

Fig. 31. Cephalic view of head capsule of *Crambus vulgivagellus* larva.

Plate IV

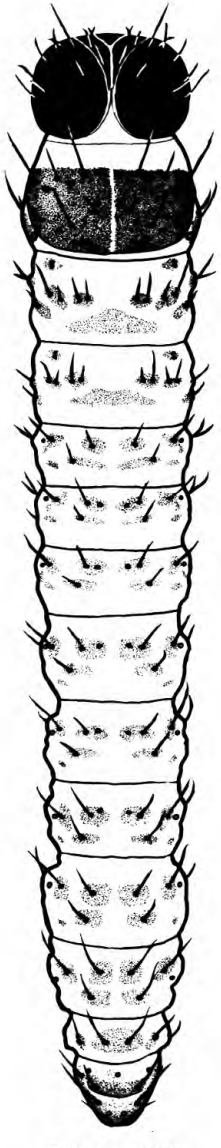

Fig. 27.

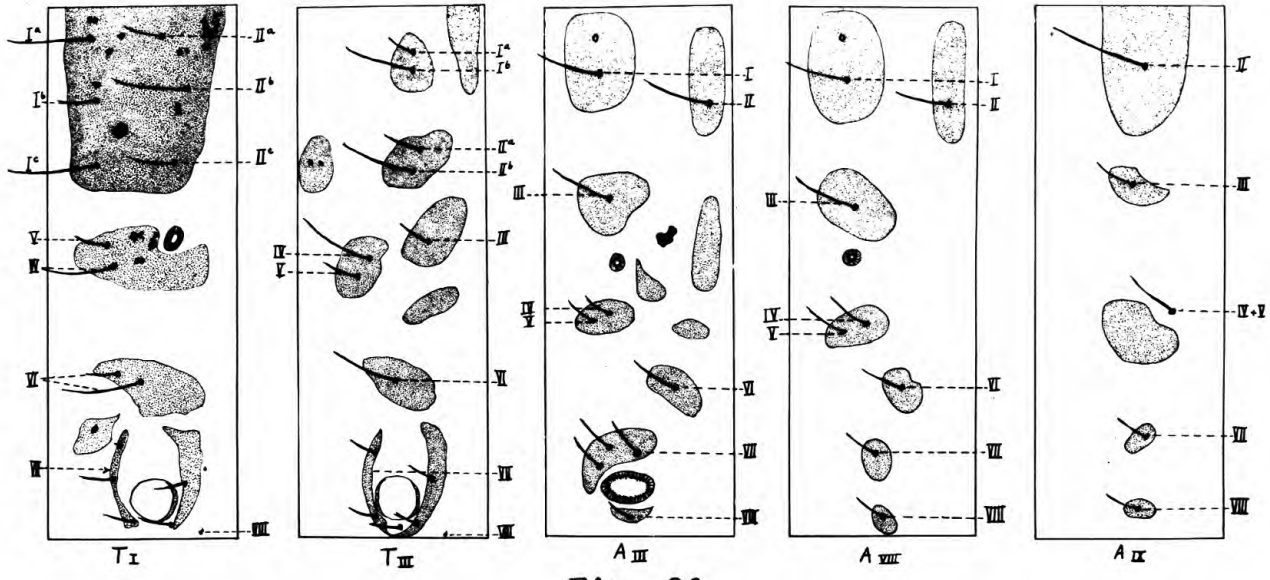

Fig. 26.

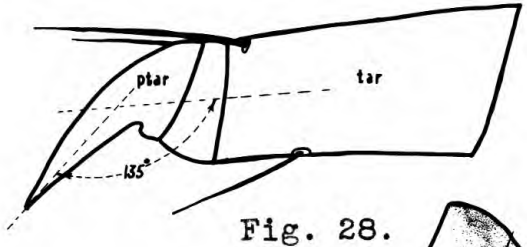

Fig. 28.

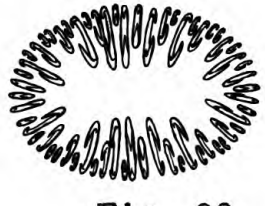

Fig. 29.

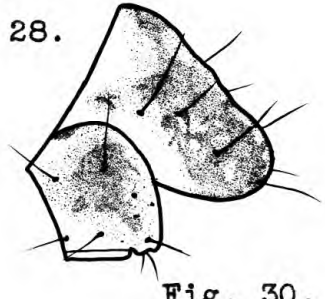

Fig. 30.

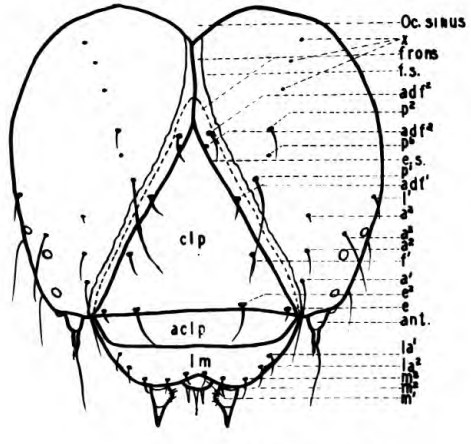

Fig. 31.

Table 6. Comparison of head capsules of *Crambus vulgivagellus*, *Stenoma mistrella*, and *Acrolophus* sp.

Name	Occipital sinus	Frons	Ocelli	Attachment of mandibles	Anta-clypeus	Clypeus	Color	Texture
C. vulgivagellus	Moderately indented	Narrow, with light band on dorsal and lateral edges	Wide apart	Concealed behind labrum	Present	Two thirds length of head capsule Basal border straight	Jet black	Smooth
Stenoma mistrella	Slightly indented	Dorsal half contiguous Ventral half wide	Close together	Medial to antennae	Present	One third of head capsule Basal border slightly concave	Light brown with dark brown blotches on dorsal half	Dark brown blotches scale-like
Acrolophus sp.	Deeply indented	Wide, with lateral edges inverted V-shaped and medial edges inverted V-shaped	Wide apart	Lateral to antennae	Absent	One half length of head capsule Basal border straight	Mahogany brown	Deep half moon fissures

ella. Insufficient number of larvae prevented a thorough study of the homology of the setal pattern of these groups.

Table 6 is based on comparison of larval head capsules of C. vulgivagellus (Fig. 31), Stenoma mistrella (Fig. 23), and Acrolophus sp. (Fig. 19). Setal labeling is according to Heinrich (1919).

CONCLUSIONS AND RESULTS

Crambus vulgivagellus Clem. was one of the commonest crambid moths in Kansas during the fall of 1938. Large numbers of the moths were attracted to lights. Females collected at lights deposited a maximum of 293 eggs. The eggs were oval with numerous longitudinal ridges. They changed from white to bright coral red during development.

The larvae hatched in 12 to 25 days. They were faint straw yellow in color with black head and cervical shield. The first stage larvae fed on minute raspings of the epidermis of leaves of grass and cereal plants. Later, small elongated pits were made between the longitudinal veins of the leaves. Within a short time the larvae migrated to the ground and there constructed loose, silken shelter tubes at the base of their food plants. The nearly mature larvae constructed larger closely woven silken cocoons, within which they aestivated and finally pupated. These cocoons

were found in a vertical position in the ground beside clumps of Andropogon grass. These cocoons were the same color as the earth. In one area the infestation of cocoons was approximately 46 cocoons per square foot.

Attempts to rear the larvae to maturity both in the laboratory and in the field were unsuccessful. They lived longer on brome grass than any other food plant. The larvae could not be found in the field this spring. Apparently the hot, dry fall has been a factor in reducing their number.

The pupal period was approximately 10 days to 2 weeks. The first adults emerged about the middle of September.

Among the recorded list of parasites 10 specimens of Lissonata frigida (Cress) were reared from C. vulgivagellus cocoons. These pupated within the cocoons and emerged about the same time as C. vulgivagellus adults. Bittacus occidentis Walker was observed as a predator upon C. vulgivagellus adults at lights. This predator record is new.

No opportunity presented itself to work on control measures of Crambus larvae.

Partial life histories of C. mutabilis Clem. and C. hemiochrellus Zeller have been completed. The moths of both of these species resemble each other closely. Adults of C. mutabilis and C. hemiochrellus were first observed at

lights about the middle of May, 1939. One female of C. mutabilis laid 180 eggs and another female of C. hemiochrellus laid 244 eggs. Slight differences in size and color could be noted between the eggs of the two species. The first stage larvae of these species were typical of Crambus sp. and could not be differentiated as to species. Both species of larvae caused typical Crambid injury to food plants.

Adults of Nomophila noctuella D. & S. have also been found in alfalfa fields in numbers. Their general appearance and nature of their flight in the field were similar to Crambus. The type of shelter tubes and larval appearance were almost identical with that of Crambus sp. N. noctuella. Eggs, however, were glued to the blades of grass and were oblong ovate in shape. They changed from light green to light brown in color as development proceeded.

Acrolophus sp. of Kansas, of which A. arizonellus Wlshm. appears to be the commonest, were numerous at lights this spring. Most of the adults were large for the genus and dark brown. The females were easily confused with Crambus sp. because of their similar long, labial palpi. The larvae were primarily root feeders and easily differentiated from Crambus larvae by their general color and shape and by the fact that they did not construct shelter tubes at the base of their food plants. However, before pupation

occurred the larvae constructed long, silken vertical tubes in the soil. These tubes were easily confused with those of Crambus. After emergence of the adult Acrolophus, empty pupal skins could be found protruding about half way out of the vertical tubes. Both Acrolophus tubes with empty pupal skins and Crambus cocoons were found within the same area. The larvae apparently had fed on the same food plant. Stenoma mistrella larval shelter tubes are similar to Crambus shelter tubes. The larvae have been found only on brome grass. The setal pattern and actions of Stenoma mistrella larvae could be easily confused with Nomophila noctuella.

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