

The Sources of American Corn Insects

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PREFACE

In undertaking an ecological study of the insects attacking a certain species of plant a number of difficulties continually present themselves. In the first place, an investigator can never be certain that he has completed the list of insects that have been recorded as attacking the plant in question. The difficulty is obvious when one considers the fact that none except the more important corn insects are listed as such and that there is no way to ascertain whether a given species is recorded as feeding upon corn except by a perusal of the literature dealing with that particular species; for instance, the Mexican bean beetle, *Epilachna corrupta* Muls., the gypsy moth, *Porthetria dispar* Linn., and the potato leaf hopper, *Empoasca fabae* Harr., are all notorious for attacking plants far different from corn; yet in the literature it is found that they all include corn within their list of possible food plants. From this it can be readily seen that in order to make the list complete as far as past records have gone it would be necessary to go over the food plant list of all studied insects, a task that would be almost a physical impossibility.

The problem is further complicated by the fact, of which there can be little doubt, that there are very many species of insects that feed upon the plant in question but have not been observed, or at least not recorded, as doing so. It is quite likely that many of the new species that are continually being added to the corn-insect list are not really new to corn but are just being recorded for the first time. The author may be criticized for including some of the forms given here in a list of corn insects because the record cited is of such an extremely incidental nature. However, the food plants of insects are continually undergoing changes and it would not be at all surprising if some of the insects here considered as purely incidental should in the future become rather important as corn pests, since the native food plants are approaching more and more closely to extermination and since corn apparently will continue to furnish an almost unlimited and continuous food supply because of its tremendously important place in our economy. Whether this is true or not, it is of a great deal of interest to know the range of food plants the different corn-feeding insect species are able to use to maintain themselves and also the list of insect forms the corn plant is able to sustain.

Another very important point in connection with the development of this study is the fact that nothing is known of the insects that attacked corn throughout the early history of the plant. We know but little of the vicissitudes of the Indians in their early efforts to raise corn. Insects must certainly have attacked corn in that day as now but we have no record and can only guess at the species that would likely have been injurious. Even the history of the corn plant itself is veiled in mystery since the wild or uncultivated form of the plant has never been determined. It thus becomes impossible to trace the probable evolution of forms that have been known to attack corn from the time that records of insect depredators on this plant were first taken.

In developing a classification and in naming the species considered in this paper the author has used the following accepted authorities:

"Check List of the Lepidoptera of Boreal America". 1917, by Barnes and McDunnough.

"Catalogue of the Coleoptera of America North of Mexico". 1920, by Chas. W. Leng.

"The Catalogue of the Hemiptera of America North of Mexico". 1917, by E. P. Van Duzee.

"The Catalogue of North American Diptera". 1905, by J. M. Aldrich.

"The Orthoptera of Northeastern America". 1920, by W. S. Blatchley.

"The Thysanoptera of Florida". 1918, by J. R. Watson in the Florida Buggist Vol. I, No. 4 and Vol. II, No. 1.

In case of the Aphididae, which are not included in Van Duzee's Catalogue of the Hemiptera, Dr. C. R. Cutright of the Ohio Agricultural Experiment Station has kindly supplied the correct names of the forms recorded as occurring on corn. For the few species of Hymenoptera included, consisting mainly of ants, Dr. M. R. Smith of the Mississippi Agricultural and Mechanical College has kindly furnished the accepted names.

In a number of cases where names have been changed since the time of the publications of the authorities named above and have been rather generally accepted in the recent literature, the new names have been used; for instance, *Sitophilus oryza* L. is used in place of *Calandra oryzae* L., and for the billbugs the generic name *Calendra* is used in place of *Sphenophorus*.

THE SOURCES OF AMERICAN CORN INSECTS

C. R. NEISWANDER¹

INTRODUCTION

From the time that insect depredators on corn were first noted by entomologists, injury has been known to occur most frequently in newly broken fields or those that had been in native or cultivated grasses for many years previously. Since corn is one of the *Gramineae* this is, of course, only to be expected; but an interesting problem presents itself when an attempt is made to classify the corn insects according to their relationships with the preceding or neighboring crops or wild plants. It may be noted that there are all gradations from the purely shelter-seeking and uninjurious, through the insignificant, incidental, and occasionally injurious forms, to the species that are apparently completely dependent upon corn for their subsistence. The relationship that a particular insect bears toward the corn plant in this respect is found to be dependent largely upon the original habits of the species.

In the development of this paper an attempt is made to classify the insects attacking corn according to their relationship with the corn plant and to demonstrate the sources, or the food material, from which they came to corn. This has been undertaken in several ways: (A) by making field observations on the different crop successions terminating in the production of corn and recording the insects associated therewith; (B) by a study of the different plant forms attacked by the various insect species in order to ascertain if the so-called "Botanical Instinct" has developed sufficiently to cause them to select corn because it is closely related to their former native food plants; and (C) by a perusal of the literature as it applies to the derivation of American corn insects through the demonstration of an evolution in this direction.

¹The writer desires to express his appreciation to Prof. Herbert Osborn for suggesting the project and for maintaining a stimulating interest in its development. The writer has also been aided and encouraged by a number of co-investigators; namely, the late Prof. H. A. Gossard and Prof. J. S. Houser, former and present chiefs, respectively, of the Department of Entomology at the Ohio Experiment Station; and also Dr. L. L. Huber, with whom the writer has been closely associated in European corn borer work during the course of this investigation.

For the determination of species taken on corn at various times during the progress of this work the writer is indebted to Dr. H. G. Dyar, Mr. H. S. Barber, and Mr. A. Busck of the U. S. National Museum, Washington, D. C., Mr. G. G. Ainslie of the U. S. Department of Agriculture, Lafayette, Ind., Miss Annette F. Braunn of Cincinnati, Prof. J. S. Hine of the Department of Zoology and Entomology, Ohio State University, and Dr. J. R. Watson of the Florida Agricultural Experiment Station.

In order to make the known corn-insect fauna more or less complete as it applies to America, the author has included as a subordinate part the insects known to attack corn in storage. Since corn is a fairly new entrant into the history of the civilized world as compared to many of the other cereals, the evolution of stored-grain insects as pests of corn can be traced in the same sense as those attacking the growing corn plant.

HISTORY OF THE CORN PLANT

At the time of the discovery of America by Columbus, corn was being grown from Canada to Chili and the Argentine. (Plate I). It had already reached its physical limits (183). The plant had undergone so much of an evolution and had progressed so greatly as an economic plant that it was entirely dependent upon mankind for its propagation. At the present time in spite of extensive investigation the species is known only in the cultivated form. This leads to one of three conclusions in regard to the history of the plant: (A) that the native habitat was so restricted that the locality has not yet been explored; (B) that the wild ancestral form has become extinct; or (C) that the plant has been cultivated a tremendously long time—so long in fact, that in its present form its resemblance to its wild ancestor is so remote as to have escaped detection.

It is thought by many botanists that the original home of the corn plant was in the highlands of southeastern Mexico or Central America (167). As far as North America is concerned, this region seems to have been the center of distribution, from whence it came into and spread over the United States. It will be so treated in this paper and a few species of insects will be associated with it in migration. A number of other botanists, on the contrary, maintain that there is insufficient evidence to warrant a definite conclusion that corn is indigenous even to the American Continent.

Regardless of the location of the native home of the plant, it is safe to say that in 1492 corn was not being cultivated anywhere in the world except in America. Consequently, we may assume that corn is a relatively new food plant for all exotic insects now distributed in this country whether or not they had fed upon corn before their importation. Thus, such a pest as *Pyrausta nubilalis* Hubn., however much it may prefer corn to all other hosts at the present time, must certainly have developed into a corn feeder since early in the sixteenth century when corn was first taken to Europe from the New World.

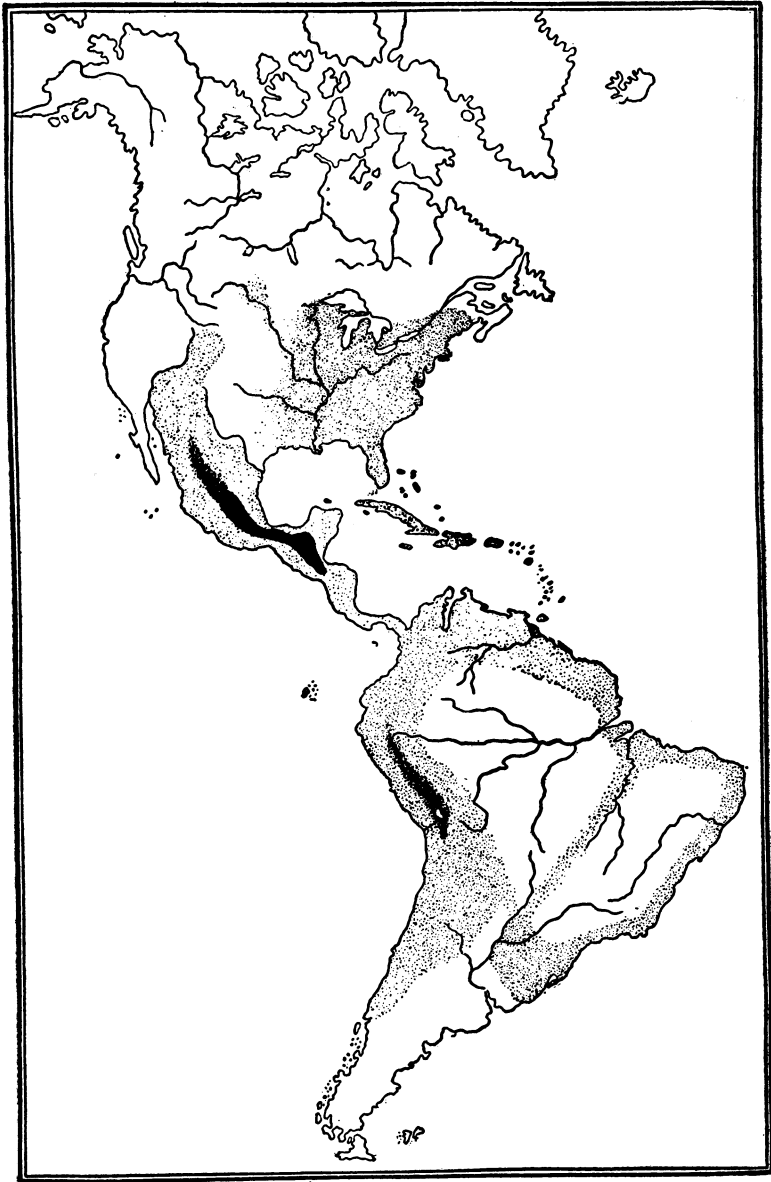


Plate I

Distribution of maize in aboriginal America. The densely shaded portion in Mexico and Central America is the probable place of origin of maize. In other portions of this map the density of the shading indicates the relative importance of maize as a crop plant. (From *The Story of the Maize Plant* by Paul Weatherwax, with the consent of the author and publisher.)

During this last four hundred years, despite the accumulated information and increased skill in plant breeding, comparatively little has been added to the work of the Indians in the development of corn as they had already produced all of the leading types. The number of centuries or the number of millenniums of growth required to attain the present stage of development of the crop is, of course, only conjectural, but during this long period of time, as the corn plant was being cultivated more and more widely, over the prairies and in the deciduous forest regions, the native insects had opportunities to begin feeding upon it and to develop an adaptation to this new host. Some of the white grubs, cutworms, wireworms, billbugs, and webworms must have attacked the plants somewhat as they do today. Since by more extensive cultivation the corn plant came to replace so many of the native plants it was to be expected that many insect species that had not developed a monophagous habit either would be able to turn at once to the corn plant for their food supply, or, through the process of evolution as applied to feeding habits, would gradually come to feed upon corn, when placed in a corn environment, until finally the new plant would become an acceptable or even a preferred food.

It is likely that the change in feeding habits from native plants to corn was not nearly so rapid in the early history of the corn plant as in recent times, because, while the region over which corn was grown by the Indians was very extensive, the acreage actually devoted to corn was insignificant as compared with the present. The corn fields were small and the original food plants of the insects were readily available. Consequently, there was no racial urge for corn feeding. Later, when all available land was planted to corn or other crops the more complete removal of original food plants caused much more rapid changing to corn.

If a contemporary economic entomologist with present day knowledge were able to make a study of the insects attacking corn in the fields of the Indians as they were at the time of the discovery of America or five hundred years before, he would have an intensely interesting problem, although the number of species he would find would likely be very small compared to present day lists. It is probable that only a few of the present day corn insects had been corn feeders before cultivation began under the regime of the white man.

RELATION BETWEEN CORN INSECTS AND HOST PLANTS

Among the plant-feeding insects there is a wide variation in the number of food plants attacked by a given species. Comparatively few are monophagous; that is, they feed upon a single plant species and will die if denied this natural host regardless of what other hosts are available. Insects reach this stage in their relationship to a given host only after a long period of association and adaptation. A larger group of insects are oligophagous and feed on a few chosen species of plants. In this group are the species that display the "Botanical Instinct" in selecting plants that are closely related. There is also the polyphagous group of insects which may be said to feed upon almost any green plant.

Based upon habits of this kind a great diversity of behavior occurs among the species included in the corn-insect list. There are forms that migrate to corn for shelter and are unable to feed upon it because of some selective adaptation, as is true of *Pyrausta nubilalis* Led., balanced, on the other hand, by forms that apparently are absolutely confined to the corn plant and obliged to feed there or die, as seems to be true of *Diabrotica longicornis* Say. Intermediate between these two groups are forms varying from those that feed on a few of the grasses, as is true of some of the billbugs, through those that feed upon any grass or grass-like plant as do the white grubs, to the general feeders that attack almost any green plant.

In the present discussion are included 389 species of insects that have been recorded as attacking corn in some manner in America. Of this number, 352 attack the corn plant; while the remaining 37 feed upon the grain in storage. Of the species that attack the plant both in the field and in storage, part are included in the one group and part in the other, depending upon the circumstances under which the injury occurs. A few of the records cited might be considered as almost obsolete, their inclusion being based on some old and unusual report that has not been verified by later observations. Perhaps also, some of the more recent records will go unsupported in the same way.

THE ORIGIN OF AMERICAN CORN-FEEDING INSECTS

At the time of Forbes' comprehensive work on the corn insects of Illinois in 1905 there were approximately 225 species recorded as corn feeders. In the 25 years that have elapsed since that time the corn plant-feeding group has been increased by about 125 species. No doubt, many of this number have been added during

the past quarter century, because of more consistent study and more prompt reporting of injury, however slight, by entomologists as a whole. This would be the natural result of the marked development of economic entomology during the period. Nevertheless, it seems certain that the number of corn-feeding insects is constantly increasing. During the next twenty-five years there will undoubtedly be a number of new species to enter the group although the increase will probably not be as great as in the last two decades.

The question naturally arises as to the sources from which these insects come. Geographically, they may be classified conveniently into two groups: (A) foreign insects that may be imported as corn feeders or may become corn feeders after importation; and (B) native species that normally have had other feeding habits.

(1) IMPORTATION OF FOREIGN CORN-FEEDING SPECIES

Inasmuch as foreign insects are continually being imported into this country, and since, when once present, they often become our most serious insect pests, it is essential that the group should be mentioned here. As an illustration of the importance of this source we need only refer to the European corn borer, *Pyrausta nubilalis* Hubn., which recently has caused a furor in American Economic Entomology, or to the species included in the "Stored-Grain Insect" group, a large proportion of which undoubtedly fed on the small grains in Europe before corn was known to civilization.

The classification scheme (Plate II) has been made to include both indigenous and exotic insects that attack corn in America. It may be noted that foreign insects are not allotted a definite place in the classification, and do not necessarily come to corn through the sources indicated for American forms. Due to the fact that before entering the United States, they had already developed a preference, or perhaps a tolerance, for the corn plant as food, they may enter any one of the ecological groups. Their entrance position in the classification would depend upon their relationship to the corn plant and their native food plants at the time of importation. As an illustration of this condition, *Pyrausta nubilalis* Hubn. (single generation "strain") enters the group described as "Corn Insects dependent upon Corn", because of the fact that when introduced it had already developed to the point where it preferred corn to all other plants.

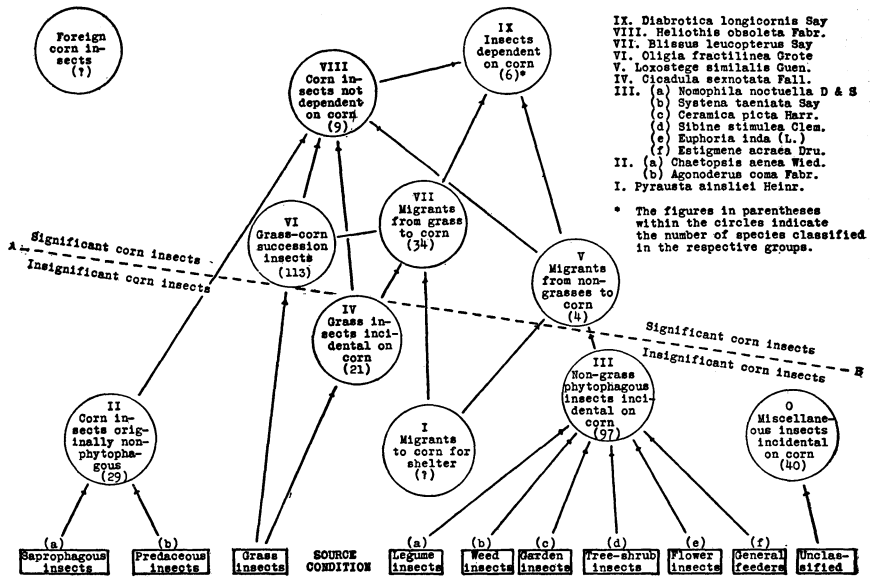


Plate II
 Diagram Showing Derivation of Field Corn Insects

(2) CHANGE OF FOOD HABITS IN NATIVE SPECIES

In general terms, all plant-feeding and all grain-feeding species, as well as many predaceous and saprophagous forms, might be considered as potential corn insects. If one cared to be speculative, a list could be made of insects that, while not yet recorded as feeding upon the corn plant, might be expected to do so. However, since insects in selecting their food plants exhibit great variability, no such list is attempted.

On Plate II is a diagram showing the varying relationships that the various species maintain toward the corn plant. The sources from which they have come to corn are indicated in the lower part of the diagram and are discussed in a general way in the following pages. The different groups are taken up in the inverse order of their ecological importance as corn insects.

I. SHELTER-SEEKING INSECTS

This group is of no special economic importance in the growing of corn. It is included here because of the interesting relationship the shelter-seeking insects have to the corn plant and to the other more economic groups. A few of the larvae are of interest because of their association and confusion with the Euro-

pean corn borer in tunnelling into plants. The group may be made as large as one may desire, not because so many insects habitually seek out the corn plant as a favorable place in which to pass the winter, but because corn plants form a conspicuous part in many environments and incidentally furnish a satisfactory place for hibernation. In a few cases, however, the plant seems to be remarkably well fitted for the winter quarters of insects such as *Pyrausta ainsliei* Heinr. and *P. penitalis* Grote. This is apparently due to the fact that the pith can be nicely hollowed out to make the type of burrow the species habitually use. The loosely fitting leaf sheath also serves as an excellent place for insects to crawl behind. *Pyrausta futilalis* Led., for example, seems to prefer this position for hibernation.

It is conceivable that through such an association as described some of these forms may come to feed upon the corn plant. As an illustration, the smartweed borer, *Pyrausta ainsliei* Heinr., is known to feed by preference on *Polygonum*. It has been recorded for a number of years as hibernating in corn, always, however, near where *Polygonum* has been growing in the field. During more recent years this insect has been taken in the corn plant in the summer while the plants are still green and succulent. In its later larval stages, it seems certain that the species will feed upon the corn plant, although perhaps at the present time it could not yet maintain its complete larval growth upon it. Further changes in its feeding habits may lead to the complete acceptance of corn as a food plant.

Because of the possibility that shelter-seeking insects may vary their relationship with the corn plant by actually feeding upon it, the group is connected with corn-feeding groups as a source of corn-feeding insects. (Plate II). In fact the three species discussed in this group as type species are included in the list of corn insects because of the nature of their habits. It must be stated, however, that if this group is a source of corn feeders it is a very minor one.

Shelter-seeking insects may be derived from almost any condition under which insects live. The group is not limited or defined in any way by the feeding habits of the species other than that those that fed in the immediate environment of corn would be more likely to hibernate in or near corn plants. Naturally, a number of the corn-feeding species themselves seek shelter amid corn stalks and back of corn leaves. Because of the fact that these have a closer relationship than that of mere shelter, they are included elsewhere in this discussion.

II. CORN INSECTS ORIGINALLY NON-PHYTOPHAGOUS

There are a number of species included in the corn-feeding insect list that normally are not plant feeders. An analysis of the habits of the members in this group shows that they are about equally divided between saprophagous and predaceous forms. Ordinarily, the members of the group are of but little economic importance. In a few instances, however, injury has been reported as due to species listed here.

(a) **Saprophagous insects.**—There are included here twelve species that have been reported to feed upon the corn plant. Usually they attack the plant after decay has started either as a result of injury by other insect species, or because of unfavorable weather conditions. The corn stalk maggot, *Chaetopsis aenea* Wied., is a very common member of this group. The larva of this species is frequently found in decaying portions of the stalk, where other insects have been feeding or where superfluous amounts of water have been retained. The species no doubt serves to accentuate former injury and causes decay to spread. Normal uninjured plants are sometimes said to be attacked by this insect but such attacks must be rather unusual.

A number of the saprophagous insects in this list breed normally in manure. These sometimes attack seed corn and seedlings when planted in ground that has been manured. The common seed corn maggot, *Hylemyia cilicrura* Rond., which is known also to attack a great many other plants, is usually recorded as injurious only after heavy manuring or during cold, wet seasons when decay has already started the injury.

(b) **Predaceous insects.**—Among the insects ordinarily considered as predaceous on other animal forms, there are 17 species that are recorded as attacking corn. These include mainly (A) a few predaceous ground beetles (Carabidae) that sometimes attack seed corn, (B) a few ladybird beetles (Coccinellidae) that occasionally feed on pollen or the leaves of corn, (C) a few predaceous bugs that have been known to suck the sap from fresh grains of corn or from other parts of the corn plant, and (D) a few tree crickets, which in the earlier nymphal stages are predaceous, later including pollen grains in their food.

In general, the food of all of these species consists largely and primarily of other insects. No doubt, one of the most important members of the group economically is the ground beetle, *Agonoderus coma* Fabr., which is very frequently reported as attacking seed

corn, in some instances the injury being reported as rather serious. The species also commonly attacks corn in the ear, especially when fallen.

III. NON-GRASS PHYTOPHAGOUS INSECTS INCIDENTAL IN OCCURRENCE ON CORN

As shown by the diagram (Plate II) the insects included in this group are those that have been recorded as feeding on corn but which feed normally and by preference on plants other than the grasses. Their occasional feeding on corn is perhaps due to the local absence of their preferred food and the coincident presence of corn together with the non-occurrence of any selective adaptation that would preclude their feeding on the corn plant.

While this group is extremely large, 97 species being included, the damage to corn by them has been almost insignificant. Nevertheless, many of them must be considered as potentially important corn feeders. It can be expected that a number of the incidental corn insects, that are not too closely restricted to their native hosts, will become increasingly inclined to feed upon corn because of the enormous food supply furnished by it. In that they have been observed feeding upon corn, they have already demonstrated their ability to accept it as a food. Some of them may eventually do sufficient feeding on corn to cause occasional damage, or may even migrate to corn at certain seasons, as seems to have been the case with the garden webworm, *Loxostege similalis* Guen., and the sugar beet webworm, *Loxostege sticticalis* L. By further changes in feeding habits they may come to feed indifferently on corn or their original hosts, thus becoming independent corn insects.

(a) **Legume insects that attack corn.**—Only five species of legume-preferring insects are included in the corn list of 352 species. Not one of these species has been reported as being seriously injurious to corn plants but only as feeding upon corn under unusual conditions. The moth of one of these species, *Nomophila noctuella* D. & S., is commonly seen in northwestern Ohio during the summer, and on one or two occasions has been bred from larvae taken from corn stalks. It feeds principally upon legumes, of which red clover, sweet clover, and alfalfa are preferred.

(b) **Weed insects as corn feeders.**—Since the plants commonly called weeds are distributed through a great many different families it would seem that a group designated as "weed insects" would not form a distinct unit. While no effort is made to show a relationship between the different weed species involved; neverthe-

less, the insect group is retained in order to include the species that have the same ecological relationship to the corn plant. There are listed in this group all of the corn-feeding insects that ordinarily and preferably feed upon the common weeds of garden and field regardless of the similarity or dissimilarity of their natural food plants.

Weeds are always found growing around the margins of corn fields and commonly also within the fields amid the corn plants. Each species is attended by its own particular insect visitants. When these weeds are cut down the insects feeding upon them, unless able to migrate long distances, are frequently forced to use the corn plant as food or die of starvation. In this group there are 21 species of corn feeders, many of which likely occur on corn only when forced to by lack of their preferred food.

Among the species included here may be mentioned the pale-striped flea beetle, *Systema taeniata* Say, which seems to prefer the common ragweed, *Ambrosia artemisifolia*, and lamb's-quarters, *Chenopodium album*. It frequently does damage to many other plants, such as potatoes, cabbage, beans, and beets. The injury to the corn plant is caused either by the beetles feeding on the leaves in which are produced the characteristic flea-beetle holes, or, on rare occasions, by the larvae attacking the roots of the plant. The adults are sometimes seen in great numbers in corn fields soon after the corn appears above the surface of the ground. This species is probably the most injurious to corn of all those included as corn-feeding weed insects.

(c) **Garden and truck crop insects.**—The plants classified as garden and truck crops occur in a number of families not closely related, such as the Cruciferae, Cucurbitaceae, and Solanaceae. Practically all of the families represented by them also include wild plants upon which the truck crop insects feed. If the insect species display a preference for certain of the wild plants they are classified as weed insects. If they prefer the cultivated species they are classed as garden and truck insects. Fundamentally, it would seem that the truck crop group is artificial and that the two groups should be considered weed insects since the insect species must have fed on wild representatives of the different families before the cultivated species were introduced or domesticated. However, just as corn has been grown for some time and has been subject to selection by insects from other plants, the same is true of garden and truck crops. Some of the species that originally fed on wild plants but now prefer garden and truck crop plants may

make, and no doubt are making, still further changes in their feeding habits. Hence the garden and truck crop group becomes a source of corn insects.

Crosby and Leonard, in their Manual of Vegetable and Garden Insects (42), record 250 species of insects as being seriously injurious to garden and truck crops in the United States and Canada. The writer has listed 20 of the corn-feeding insects as being primarily garden and truck crop species. Inasmuch as the garden and truck crop plants considered as their normal hosts are not closely related to the grasses, the group as a whole would not be expected to serve as a very important source of corn insects.

Although the number of species involved here is not small, as a group they are of very little economic importance as far as corn is concerned. Their injury to corn is incidental in nature and they are apparently in no way especially adapted to the growth of the corn plant. When they occur on corn it is only where (A) their preferred food is either lacking or restricted for one reason or another, or (B) where certain individuals of a species leave their usual habitat and feed or deposit eggs incidentally upon plants other than the usual ones. In these two ways, no doubt, many of these species have come to feed upon the corn plant and thus have been recorded as corn feeders.

The members of the genus *Diabrotica* are rather typical representatives of this group. They feed primarily and preferably upon the cucurbits and in the larval stage are practically limited to plants of this family. It is in the adult stage that they attack corn. The few species that are known to feed on corn in both the larval and adult stages are included in other groups as showing a more specialized adaptation.

The zebra caterpillar, *Ceramica (Mamestra) picta* Harr., feeds on the foliage of many garden plants but becomes injurious mainly to cabbage and celery. It is sometimes found attacking corn in the late fall, feeding on the silk of the ear and sometimes on the leaves. The occurrence on corn comes from the incidental deposition of eggs on or near the corn plant. It is in a sense a migration from its normal breeding ground, although the migrating commonly is done individually and not in large numbers except in unusual cases.

(d) **Tree and shrub insects.**—The tree-foliage insects that attack corn are not numerous. Ordinarily, there seems to be a rather marked difference between the insect species that feed on the foliage of trees and those that feed on herbs, but among the

corn-feeding insects are a group of nine that are rather distinctly tree-foliage insects. One of the commonest members of this group is the saddle-back caterpillar, *Sibine stimulea* Clem., specimens of which are continually being received at the Ohio Agricultural Experiment Station after having been taken on corn. The caterpillar feeds primarily on a great variety of trees and shrubs and, according to Felt (51), is found commonly on oak and cherry.

(e) **Flower- and sap-feeding insects.**—Another group of insects that is of little or no economic importance in the growing of corn, yet is of ecological interest, is the flower- and sap-feeding group. A number of flower-feeding insects attack the pollen of corn. The adults of the genus *Diabrotica* may all be included here as they feed mainly on the flowers of many plants including the pollen of corn. Many of these species are named in other groups because of the more serious work of the larvae as root feeders. The species *Diabrotica atripennis* (Say) is listed here and nowhere else because the larval stage is unknown, and hence only the adult is considered.

Among the other representatives of this group may be mentioned the bumble flower beetle, *Euphoria inda* (Linn.), and its relatives. The adults feed upon the pollen from the tassel, exposed kernels in the milk stage, and the exudations from the stalks. They frequently occur where some agency has wounded the plant and caused the sap to flow. It has been noted that they are quite commonly associated with ear worm injury, but they also feed independently upon the soft kernels of exposed ear tips. Forbes (59) thinks that the bumble flower beetle fed originally on the sap exuding from wounds of trees.

(f) **General feeders.**—Some of the species listed as corn insects cannot be said to show a definite preference for any particular type of plant. They are phytophagous insects but are practically omnivorous on available plant tissue. Naturally, a number of species of this nature have been observed to feed upon corn. The salt marsh caterpillar, *Estigmene acraea* Dru., which is one of the common "woolly bears", is an illustration of this type of insect. The caterpillar of this species feeds on practically all kinds of cultivated field and garden crops, and nearly all kinds of weeds, as well as the foliage of many small fruits, vines, and young trees. The attack on corn is most prominent in the fall when the larvae are rather commonly seen feeding upon the silk.

Another very common member of this group is the tarnished plant bug, *Lygus pratensis* Linn. It is found throughout the United States and attacks practically all kinds of vegetable and

field crops, fruits, and weeds. The insect is of the sap-sucking type and may take the juices from any part of the corn plant. It is unlikely that the species will ever be of much economic importance in its attack upon the corn plant although in one or two cases it has been reported to do damage.

IV. GRASS INSECTS INCIDENTAL IN OCCURRENCE ON CORN

Just as there are a great many species of non-grass-feeding insects that attack corn incidentally, in like manner, there are grass insects that feed on the corn plant in a minor or incidental way. In this group are classed the corn-feeding grass insects that are not migratory in the ordinary sense of the word and are not specifically associated with grass-corn crop successions. Their behavior is not in any way inducive to adaptation as corn insects. *Cicadula sexnotata* Fall., an example of this group, lives normally in meadows and pastures but occasionally gets into other habitats, such as corn fields, where slight injury is done.

V. MIGRANTS FROM NON-GRASSES TO CORN

Of somewhat more importance than the preceding groups, but coming from the non-grass phytophagous type, are four species of insects that occasionally become migratory and at times do severe damage to fields of corn. The injury done to corn sometimes reaches the stage where it cannot be considered incidental. Their breeding habits indicate that they feed primarily on plants other than grasses and migrate to corn or other plants only when the lack of preferred food requires it.

Two of the species included here are the garden webworm, *Loxostege similalis* Guen., and the sugar beet webworm, *Loxostege sticticalis* L., both of which feed preferably on pigweed, *Amaranthus* sp., and lamb's-quarters, *Chenopodium album*. They breed normally amid patches of these weeds and spend the winter as larvae or pupae in the soil near by. The garden webworm is sometimes called the "Careless Worm" because of the fact that it is most injurious when the favorite weed hosts are permitted to grow.

VI. GRASS—CORN SUCCESSION INSECTS

If considered on the basis of the damage done, extra work caused, and losses incurred by the farmer, the grass-corn succession insects may be considered of tremendous importance. In this group are placed 113 species of insects, including such forms as the

cutworms, wireworms, sod webworms, white grubs, and billbugs. Every year some members of this group cause a great deal of damage throughout the country. Frequently, fields of corn germinate well and give excellent promise but during the first few weeks of growth are killed off by the grass insects and replanting is necessitated. The members of the group are all grass-feeding forms except some of the billbugs which feed upon the closely related sedges and rushes and so are included here.

The grass insects are largely native forms that were feeding on the prairie grasses and weeds while the country was still in the natural state. An adjustment between the native vegetation and its insect complement had no doubt been established and maintained for a long period. The grass crops grown today come most nearly to simulating primitive or uncultivated conditions, especially when they are permitted to stand for a number of years. As a consequence, the introduced grasses have become adjusted to a very large population of insects. When corn, a somewhat differently growing grass, is thrust into their natural haunt and the other grasses removed, the insects present are forced to accept the new living conditions or perish along with their former food plants. Inasmuch as the growing of corn on old grass land has been a very common procedure since cultivated crops were first grown, the grass-insect fauna has been continually thrust into a corn environment. Under these conditions it would be natural to expect that many of the various grass insects would congregate upon the corn plants.

The life histories of all of these species are sufficiently well known to warrant the statement that in practically all cases the insect individuals that do the damage were present before the corn was planted. Furthermore, they have obtained their early and slow growth from their former food plants, the grasses. Their damage is thus more significant because, while they are developing rapidly, they attack the corn before the plants have attained their most rapid growth and are still in a rather delicate and critical condition. A little later the corn plant perhaps could endure the feeding without injury.

The depredations in corn fields by the members of this group occur only after the destruction of their natural food plants. Since the infestation had been previously located in the fields through egg deposition in grass lands, it may be readily seen that attacks on corn, though frequent and destructive, are incidental in nature. The group is of great importance not only because of the

very great number of species involved and the important damage done as conditions exist at present, but also because of the possibility of its members passing into some of the groups more clearly defined as corn insects. An analysis of the corn-insect list also serves to emphasize the fact that a very great number of the species commonly reported as being destructive to corn are primarily grass insects.

The usual habit or procedure with practically all of the insects included in this group is for the females to fly over and deposit eggs in grass lands during the summer and fall. The eggs hatch in due time and the young larvae feed upon the foliage, stems, and roots of the grass and weed plants present. During the winter the partially grown larvae hibernate in the soil or amid the turf and in the spring do more active feeding in preparation for transformation to the adult stage. In some cases, as is true of some of the sod webworms, this generalized habit is varied by having two complete transformations per year; while the wireworms and white grubs usually require three to five years to develop from the egg to the adult stage. It may be noted that these habits are nicely adapted to permanent and undisturbed sod conditions but are in no way especially suited to growth in corn fields.

During the season of 1925, a year of severe sod webworm injury, records were taken from a number of northwestern Ohio fields in order to determine the amount of insect injury occurring to corn under the various kinds of crop successions leading up to corn. These records are tabulated below with the preceding crops indicated. In obtaining the percentage of plants showing injury and the estimated damage, a count of consecutive plants was made, usually in several different parts of the field. A separate record was kept of the plants severely injured and those only slightly attacked in order to obtain a fairly accurate account of the damage done.

TABLE 1.—Injury to Corn Following Legumes—1925

Field	Acres	Preceding crop	Sod webworm injury	Cutworm injury	Per cent damage
Freimark.....	12	clover	little	little	0
Knopp No. 1.....	5	clover	little	0	0
Draper.....	12	clover	0	0	0
Newcomer, H.....	30	clover	0	0	0
Filmore.....	6	clover	20%	0	10
Flick.....	15	alfalfa	0	0	0
Risser.....	27	alfalfa	5%	0	2
Knopp No. 2.....	7	alfalfa	15%	0	9
Total acreage and weighted av. of injury.	114	.....	3.2%	0	1.6

TABLE 2.—Injury to Corn Following Grasses—1925

Field	Acres	Preceding crop	Sod webworm injury	Cutworm injury	Per cent damage
Motter.....	10	blue grass	4%	5%	7
Rodebaugh.....	6	blue grass	48%	0	25
Blosser.....	7	blue grass	21%	0	13
Wagner No. 1.....	5	blue grass	75%	0	50
Wagner No. 2.....	5	blue grass	25%	0	10
Crowe.....	20	blue grass	.....	.....	80
Pugh.....	14	timothy	8%	2%	5
Fiester.....	8	timothy	20%	0	8
Emerick.....	8	clover-timothy	0	40%	40
Kesler.....	8	barley-clover	75%	0	50
Grieger.....	10	wheat-clover	0	0	0
Robinson.....	8	wheat	75%	0	50
Total acreage and weighted av. of injury.	109	.....	27.5%	4.5%	31.8

TABLE 3.—Injury to Corn Following Cultivated Crops—1925

Field	Acres	Preceding crop	Sod webworm injury	Cutworm injury	Per cent damage
Cook.....	12	corn	0	0	0
Howard.....	20	corn	0	0	0
Turnow.....	18	sugar beets	0	0	0
Anderson.....	14	corn	5%	2%	5
Total acreage and weighted av. of injury.	64	.....	1.1%	.4%	1.1

It may be noted from the foregoing tables that where the preceding crop consisted of or contained a grass, injury occurred in every case but one, and that in the twelve grass fields studied there was an average loss of 31.8 per cent of the plants. Where the preceding crop was a legume, on the other hand, only three out of nine fields showed measureable injury, the average loss for all fields being 1.8 per cent of the plants. In this survey only four fields were observed in which the preceding crop was of the cultivated type. One of these showed slight injury by both sod webworms and cutworms, the other being uninjured.

In some of the cases where injury followed crops other than grasses the presence of insects could be explained by the prevalence of weeds and volunteer grasses in certain portions of the fields. In both the Filmore and Knopp #2 fields this was the condition that existed, the fields having been plowed down because the legumes had been replaced largely by these plants.

In another instance, not included in this survey, a field was observed in which damage by Crambids to the extent of approximately seventy-five per cent of the plants occurred where corn was the preceding crop. The owner, who was apparently a very good farmer, stated that the field had been fairly free from weeds the preceding fall, although they had been permitted to develop to an

unusual extent during the early part of the season, which was wet. The species, which was determined by Mr. G. G. Ainslie as *Crambus praefectellus* Zinck., had been recorded as attacking corn on only one or two previous occasions. No explanation is attempted for this unusual injury, but considering the habits of the species it seems certain that there must have been some kind of plant growth there to sustain the young larvae up to the time the corn plants furnished food material.

As a usual thing it may be said that, in this survey, where the preceding crop was a member of the grass family the injury was significant. In a few instances there were sections of the field in which every plant was taken. The insect species involved were various members of the cutworm and webworm groups which are discussed more specifically in a later part of this bulletin.

The species listed as the designated type species for this grass-corn group is the lined stalk borer, *Oligia fractilinea* Grote. This insect is destructive to corn every year in the timothy section of Ohio where timothy of several years' standing is plowed down late in the spring and the field planted to corn. However, when such fields are fall-plowed or very early spring-plowed, so that there is a considerable time interval between the plowing down of the timothy and the planting of the corn, the injury is much less severe. In no case has the insect been observed to be destructive to corn except where timothy has preceded for two or three consecutive years. The injury to corn occurs entirely as a result of the fact that corn was planted in the specific habitat of the insect and all other food plants removed. The eggs were laid in timothy and the early growth of the larvae obtained there. Had it not been for the artificial conditions produced by the cropping system there would have been no change in food hosts and the insect would have completed its life cycle in timothy or the other grass species associated therewith.

VII. GRASS-CORN MIGRANTS

The insects that migrate from grasses to corn for feeding make up an important group and sometimes do very severe damage. The species listed here typically spend the spring or early summer part of their life cycle on grasses and then migrate to the neighboring fields of corn for the remainder of their feeding period. Practically all of the members of this group have been shown to have been grass insects originally. A study of the cause for the changed feeding conditions suggests the possibility that the

insects were induced to feed upon corn by a limitation of their native food plant and the coincident abundance of corn. At the present time some of the species have come to migrate to corn as an apparently normal adaptation; while a very few of the forms may be said to have reached the stage where they almost depend upon corn for the completion of their life cycle. Certainly the abundance of certain species would be greatly lessened if they were not enabled to make the migration.

The typical and best illustration of this migrating group is the chinch bug, *Blissus leucopterus* Say. This species is thought to have occurred throughout the prairie region long before it was settled by the European immigrants. From the time the prairies were first broken to the present, it has caused intermittent damage to corn and other grain crops. It feeds upon practically all of the grains and grasses and winters principally among the native prairie plants such as bunch grass, *Andropogon scoparius*, big blue stem, *Andropogon furcatus*, false red top, *Triplasis purpurea*, and various other species.

Civilization seems to have promoted the development of the chinch bug, especially where the small grains and corn are grown in close association. According to Headlee and McColloch (85), "Wheat is the best kind of food from spring until midsummer and corn from then until fall. In fact, it is hard to conceive of any more favorable combination of food plants from the standpoint of chinch bug life economy. Wherever wheat and other small grains alone are grown the chinch bug does less harm, for it finds extreme difficulty in obtaining food the latter part of the summer. Where corn and similar grains alone are grown the bug does small damage, because food is very scarce in the early summer." There can be no doubt that the original hosts of the chinch bug were the native wild grasses and that the insect has developed a preference for the cultivated cereals.

Another very common member of this group is the common stalk borer, *Papaipema nitela* Guen. When this species is recorded as attacking corn, it is nearly always in a small sweet corn patch or in the marginal rows of a field. In order to ascertain definitely whether or not the stalk borer occurs on corn as a migrant from weeded or grass areas around the field margin, a study of the nature of the infestation in corn was made.

Injury by this species was observed in a small garden plat of sweet corn which, together with a few other truck crops, occurred beside a peach orchard in Ottawa County, Ohio. The orchard had

an almost pure stand of timothy and clover, there being scarcely any weeds present. The sweet corn plat consisted of six rows and lay adjacent to the orchard, the other truck crops occurring on the opposite side of the sweet corn. When this plat was first examined on July 15, 1924, the corn was found to be very severely damaged. The two rows adjacent to the orchard were almost completely destroyed as a result of the work of the borers, the tops of most of the plants being dead. An infestation count was made over the whole plat, the record being given below.

TABLE 4.—Plat of Corn Infested by *Papaipema nitela* Guen., Showing Migration From Adjacent Source

No. of row	No. of hills in row	No. of infested hills in row	Per cent infested
1.....	43	37	86
2.....	53	41	77
3.....	59	27	45
4.....	63	9	14
5.....	64	5	8
6.....	64	5	8

In the table above the rows are numbered from the margin along the peach orchard. It may be stated also that all of the five infested hills of each of the fifth and sixth rows occurred at or near the ends of the plat, and hence may have been, and likely were, infested from the end grass margin instead of the orchard margin. The nature of this infestation seems to indicate that without doubt the timothy or clover in the orchard was the source of the infestation in the plat.

Another case of rather extensive injury to corn by this species was observed in a field near Woodville in Sandusky County, Ohio. This field had been permitted to grow up in weeds for several years, and no effort had been made to grow or harvest a crop. The field was situated along the road. There was no fence and only a shallow ditch leaving an uninterrupted strip of grass about twelve to fifteen feet wide that formed a margin for the field on this side. The field had been poorly plowed and not well cultivated, and had a poor stand, particularly in the part near the road.

When this field was visited early in July a large number of stalk borers was seen to be present. Near the grass border along the road, practically all of the plants were infested or had been at one time. Borers were found in plants 150 feet from the grass margin and about thirty per cent of the plants were infested as far as 100 feet into the field.

From the fact that the plants nearest the road were practically all infested, and since the infestation decreased gradually as one progressed toward the middle of the field, it can be readily seen that the road border was the source of the infestation. Perhaps not all of the borers within the 100-foot zone came from the road border. In fact, occasional fields have been seen where injury occurred throughout the field. In all such cases observed, however, the field had been poorly plowed, some of the grass and weeds not being completely turned under. Consequently, some of the young larvae, hatching from eggs not deeply covered, or perhaps not covered at all, were able to survive on some of the remaining grasses. Large fields cleanly plowed and well cultivated seldom, if ever, have been found infested with stalk borers anywhere except around the outside. The above records and other observations clearly indicate that the eggs of this species are deposited in grass lands and that the young larvae, after feeding for a time on the grasses, migrate to larger stemmed plants such as corn.

Grasshoppers also make up a very significant part of this group. While they feed on practically all kinds of vegetation they are classified here because they breed normally in grass lands and migrate to surrounding fields. Grasshoppers intermittently become very seriously injurious to corn. According to Comstock², "The most terrible of insect scourges that this country has known have been the invasions of this species (*Melanoplus spretus* Uhl.). Large areas of country have been devastated, and the inhabitants reduced to a state of starvation."

VIII. MAJOR CORN INSECTS NOT DEPENDENT ON CORN

Under this heading are included those forms which are essentially corn insects but which would not be greatly diminished in abundance if the corn plant were exterminated. Species in this group may devote their entire life history to the corn plant and sometimes do become very destructive. They are independent, however, in the sense that they are not restricted to the corn plant for sustenance. In fact, individuals of a species may be as abundant on a few other plants as on corn.

The species of this group are much more significant as corn insects than any of the groups discussed up to this point. Their injury is not incidental nor occasional but usual. They are not limited to grass-corn successions where injury results because the species is thrust into an environment of corn, and they do not occur

²Comstock, J. H. Introduction to Entomology, 1924.

as migrants to the corn plant from the neighboring grasses or weeds. They may be considered in a sense as a climax group, although some of the species may pass over into the next division where they are more completely dependent upon the corn plant.

In this group the eggs are deposited directly upon the corn plant or in its immediate vicinity, the type of life history being much more closely coordinated with the growth of the corn plant. In other words the species included here form a higher type of corn insect than those discussed in the preceding groups. On the other hand, the eggs of these species are also deposited habitually on other plants and the young insects developing therefrom apparently grow just as well as those deposited on corn. Their numbers are seemingly just about as great on one plant host as on the other. Their original food plant, however, must have been something else than corn since corn is strictly a cultivated plant.

An excellent illustration of the independent type of corn insect is the corn ear worm, *Heliothis obsoleta* Fabr. This species occurs throughout the United States and is present practically everywhere in the world between the parallels of 50° North and South Latitude. It seems to prefer corn to all other hosts but is also a very severe pest on a number of other plants. In addition to being known as the corn ear worm, it is called the cotton boll worm, the tobacco bud worm, and the tomato fruit worm when it attacks these various plants. It also feeds on beans, peas, vetch, cowpeas, alfalfa, and many other garden and forage crops.

Apparently, the only monocotyledonous plant among the more prominent hosts of this species is corn. The nature of its food plants would indicate that its native hosts were plants other than grasses, probably legumes or plants closely related to legumes. It thus seems to be one of the originally non-grass-feeding species that has become a major corn insect. It no doubt first occurred as an incidental feeder on corn but later developed into a very important corn insect although not yet losing its ability to feed on its original food plants. At the present time, while it prefers corn to other hosts, it apparently is not greatly restricted by the absence of corn but can increase to great numbers on other plant species.

The species passes the winter as pupae in the ground near where the larvae had been feeding, but, since the moths emerging from these pupae may fly considerable distances before depositing their eggs, the immediate environment is of little importance as far as the destructiveness of the species is concerned. For this reason damage by this insect is seldom more severe where corn is grown repeatedly than where definite crop rotations are practiced.

The number of generations each year varies from one ordinarily in the northern section of the United States and Canada to four or five in the far South. In northern Ohio in 1925 there was evidently at least a partial second generation as shown by the table below. The sweet corn grown in the European corn borer varietal plat work at Bono, Ohio, was picked twice a week beginning August 6th and continuing until the last was harvested on September 31st. The ear worm infestation was recorded for each picking and is tabulated below.

TABLE 5.—Ear Worm Infestation in Corn, Lucas County, Ohio, 1925

Date of picking	No. of ears picked	No. of ears injured	Per cent of ears injured
Aug. 6.....	457	22	4.8
Aug. 10.....	953	26	2.7
Aug. 13.....	1021	19	1.8
Aug. 17.....	2331	24	1.0
Aug. 20.....	2349	22	.9
Aug. 24.....	1752	20	1.1
Aug. 27.....	1658	21	1.2
Aug. 31.....	3507	62	1.8
Sept. 3.....	1044	15	1.4
Sept. 7.....	1557	31	2.0
Sept. 14.....	1409	145	10.3
Sept. 21.....	78	9	11.5

As may be noted from the table there was a comparatively heavy infestation period when picking first started and a still heavier one at the close of the harvest. The corn that was picked on August 6th had been planted on April 29th and May 8th, while that harvested on September 14th and 21st had been planted on June 9 and 19th, with all other plantings coming between these two extremes. No sweet corn planting was made later than June 19th, but a plat of Clarage field corn, that had been planted on July 3rd and was 40 per cent silked on September 1st, had an infestation of 69 per cent on October 15th. The larvae on this date varied in size from very small individuals to those full grown.

The larvae of the August 6th picking were taken to the laboratory and reared to adults. They were nearly full grown when taken and by August 13th had all gone into the ground for pupation. The first moths to emerge were seen on August 31st although two individuals had apparently emerged a day or two before being observed as their wings were badly beaten. The larvae taken on September 14th and 21st were undoubtedly the progeny of the moths emerging during the latter part of August although no matings were observed. If this assumption is correct there was a partial second generation of larvae as well as moths. It may be stated that the same general condition of infestation was observed in 1924 although no definite records were taken.

Another major corn insect, one "strain" of which has been classified in this group, is the European corn borer, *Pyrausta nubilalis* Hubn. Coming to America from Europe where it was already recognized as a corn insect, it was soon seen to be a species of tremendous potential importance. Inasmuch as it could not have occurred on corn longer than the three or four hundred years that corn has been grown in Europe, it furnishes an excellent illustration of the changing of food habits in insects due to the changing of the environment. In the comparatively short period that has elapsed since the species was first associated with corn, it has developed to the point where it must be rated as being distinctly a corn insect and one of very grave importance.

A peculiarity in the food plant reaction of the European corn borer is the fact that in different localities it behaves like two different species. As a result of this variation in reaction the term "strain" has been used by some writers to designate the differentiated types (21). In the two-brooded area around Boston the insect seems to be but slightly dependent upon corn, if at all. In this area the species feeds upon a great variety of plants not necessarily occurring in the vicinity of corn. Patches of cocklebur and pigweed, as well as potato and tomato, are heavily infested with borers when no corn is near. The borer population seems to be just about as heavy in one locality as another wherever food material permits, the main requirement seeming to be an herbaceous-like stem sufficiently large for tunnelling.

In the infested area around Lake Erie occupied by the single-brooded "strain", on the other hand, the insect seems to be distinctly dependent upon corn for food. It is very seldom found in plants other than corn except where these plants are closely associated with corn, and its presence in them can usually be traced to migration (91). In Canada the corn borer has been found to infest oats slightly where oats had been sown in a corn field that had been very heavily infested the preceding year. The larva has also been taken in a few instances in other plants under conditions which indicated that it had completed its growth upon the plants in question. Nevertheless, there is no doubt that the species is quite dependent upon corn in this western area and, were corn not grown, its numbers would at least be very much diminished. It thus seems that the European corn borer from the host standpoint should be classified in two separate groups, the single-brooded "strain" being considered dependent and the two-brooded "strain" independent.

Because nothing much is known about the biology of insects previous to the past two centuries, it is difficult even to surmise what may have been the path of evolution in the development of this species as a corn insect. The principal food plants in the old world are corn, *Artemisia*, hemp, hops, and millet. In some parts of Europe it is known as the millet borer, and it is also recorded as attacking a number of other grasses. This might seem to indicate that it had developed on certain of the thicker stemmed grasses. On the other hand, however, it seems to be a more severe pest of hops than of millet, and also rather severely attacks hemp, two species of plants which are not at all closely related to the grasses. Some European investigators maintain that the preferred host is *Artemisia vulgaris* a member of the composite family. A very great many other plant species, including widely divergent types, are listed as being hosts of the corn borer. Because of this dissimilarity of known host plants no definite statement can be made in regard to its source as a corn insect.

A third important member of this group is the spotted cucumber beetle, *Diabrotica duodecimpunctata* (Oliv.). This species is frequently injurious to corn from Maryland and southern Ohio southward. While it perhaps does more damage to corn than to any other host, it will feed quite readily in both the larval and adult stages on a number of plants. The larvae attack wheat, rye, millet, and Johnson grass in a way similar to corn, and the roots of melons and other cucurbits are often so riddled by them as to kill the plants. The species hibernates in the adult stage and the eggs are deposited in the ground in the spring. Severe injury has been observed in southern Ohio both where corn follows corn and where corn follows grass. Thus, the crop succession does not determine the destructiveness of this species. Early and late planting are sometimes practiced as control measures.

The corn root aphid, *Anuraphis maidiradicis* (Forbes), is placed in this group because it is a rather important corn insect under certain conditions and is also found throughout the season on the roots of a number of weeds. The eggs of this species are not deposited upon or necessarily near the corn plant, as is true of typical members of this group, but the spring forms are transported to the roots of corn by ants. While not particularly adapted to corn, in no sense are the living habits of the insect of a sort that would prevent its feeding upon corn. Because of the fact that the species is carried over the winter as eggs in the nests of ants, and because ant nests tend to accumulate in fields repeatedly in corn,

the corn root aphid becomes more numerous and destructive where corn is grown continuously for a number of years. In this respect it seems to be somewhat dependent upon the corn plant for maintaining its most complete development, but since even under conditions of this kind it is also found on the roots of various weeds throughout the season, it is classed here as a major corn insect that is not dependent upon corn.

IX. INSECTS DEPENDENT UPON CORN

The insects included here are species that attain their greatest vigor and largest numbers on corn. While able to feed in a measure on other plants, their accumulation is restricted. They are the forms that have become the most highly specialized as far as being corn insects is concerned and may be considered as forming the climax group. The theoretical climax group would consist of those species that feed upon nothing else but corn, the extermination of which would lead also to the extermination of the species. Perhaps not a single species has yet reached the stage where it would be completely exterminated if corn ceased to be grown. Even with the characterization used for this group, the number of species occurring here is quite small.

The pre-eminent example of this group is the western corn root worm, *Diabrotica longicornis* Say. This species seems to have developed to the point where it is very distinctly limited to corn at least as far as increasing in great numbers is concerned. Although a great amount of skilled attention has been given to the study of the insect it has never been found feeding in the larval stage on any other plant. Because of the fact that the eggs are deposited in the fall around the stubble in old corn fields, it becomes destructive only when corn is grown repeatedly in the same field. "There is not an instance on record in which corn has been injured when planted on land following a crop of small grain such as wheat, rye, barley, or oats" (172).

The members of the genus *Diabrotica* that occur in the United States seem to have spread northward from the Neo-tropical regions. In fact, more than ninety-five per cent of the members of this genus still occur south of the United States. *Diabrotica longicornis* Say ranges from Yucatan north through Mexico to Buffalo, New York, and into Canada, occurring over most of the United States east of the Rocky Mountains. Since it seems certain that on this continent corn was first grown in Mexico or Central America and has spread from that region northward, it is possible that

this species may have been associated with its host, the corn plant, in tropical or subtropical regions. This would provide a longer period for adaptation than other and native species that attack corn have had and may serve to explain the more complete dependence of this insect upon the corn plant.

On the other hand, Webster (172) advanced the idea that the species has very recently developed a corn-feeding race and that as a species it had occurred in limited numbers over a large part of North America before it was known as a corn feeder. Whether or not this is true there seems to have been a gradual trend to the northeastward over the United States as far as feeding on corn is concerned. It first became injurious in Kansas. In 1875 it was very infrequent in occurrence in Illinois and up to 1900 was not known at Wooster, Ohio. Only within the last few years has the species been taken in Connecticut, but the beetles are now seen there quite frequently on many of the common flowers.

The species has not become highly adapted to the cultivation of corn as shown by the fact that the eggs are deposited in the ground near where the old plants occurred. For an insect feeding upon wild growing plants this would seem to be a splendid adaptation, as the new plants would be more likely to occur near the old stubble than elsewhere. But when corn is grown in different fields each succeeding year, as is common under modern crop practices, the larvae hatching from the over-wintering eggs have no corn plants near at hand upon which to feed. The fact that it becomes increasingly destructive the more a corn-corn succession is practiced indicates a close association with and adaptation to the corn plant as food material.

The adult *Diabroticas* are primarily flower feeders and prefer the blossom to the foliage. The larval forms are root feeders that attack mainly Cucurbitaceous plants. While the western corn root worm, in the larval stage, has never been recorded as feeding on any host other than corn it is very likely that the larva does feed on other plants at least to a slight degree. The insect seems to have developed so much of a preference for the corn plant that its other feeding habits have become insignificant. Webster (172) concluded that in the larval stage the species was originally a grass-root-feeding insect. There seems to be little foundation for this belief, however, when the habits of other species of the genus are considered, the main reason for the assumption being that it feeds upon corn, and corn is itself a grass. The fact that practically all of the other North American species of this genus feed on

cucurbits would suggest the probability that this species was also a cucurbit feeder originally. No attempt is made here to show the source from which this species came to corn but it is suggested that it may have been associated with the corn plant sufficiently long to have developed a physiological adaptation to it and to have lost its original feeding habits almost entirely.

Among the other species included in this group is *Diabrotica vergifera* Lec., which occurs in Colorado and has habits almost identical with those of *D. longicornis*. The southern corn leaf beetle, *Myochrous denticollis* Say, is included here rather doubtfully. The species is destructive to corn only after corn has been planted in pasture fields and waste lands that have not been disturbed for several years. This seems to indicate that it is fundamentally a grass or weed insect, but the larvae have never been found on the roots of any plant except corn. The adults feed upon a number of plants, but from the known larval habits the species at present may be said to be dependent upon corn for its maximum development.

The corn leafhopper, *Peregrinus maidis* Ashm., is a tropical or sub-tropical form and does not occur in the United States except in the extreme southern part. It drains the leaves of sap and causes a rapid withering of the plants. The species seems to prefer corn to any other plant but has been recorded as feeding on native grasses in the Philippines and a Mexican grass in Cuba (Prof. Osborn). Its native locality is not known but it probably fed originally on members of the grass family somewhere in tropical regions.

The larger corn stalk borer, *Diatraea zeacolella* Dyar, is frequently very injurious to corn in the southeastern states from Maryland south to the Gulf of Mexico. Corn seems to be the main and preferred food of this insect. It spends its entire life cycle on this plant, hibernating in the stubble. In addition to corn, however, the species feeds on a number of plants belonging to the grass family. No doubt, its original food consisted of the larger stemmed native grasses.

The final member of this group is the so-called single generation "strain" of the European corn borer, *Pyrausta nubilalis* Hubn. This "strain" occurring in the area surrounding and adjacent to Lake Erie is dependent upon the corn plant, at least for multiplication to great numbers. From a study of its behavior to date, some evidence exists, but it is by no means conclusive, that the extermination of corn in this area might also result in the extermination of

this insect, since but a few cases only have been observed where infestation of a primary character occurred on plants other than corn. This is true in spite of the fact that the larvae will feed quite readily on a number of other plants as shown in restricted feeding experiments (91), its limitation to corn being due to the fact that the moths, in nature, deposit eggs only on corn. Considering the general behavior of the single generation "strain" it must be classed as a dependent corn insect.

O. MISCELLANEOUS INSECTS INCIDENTAL ON CORN

There are 39 species of corn-feeding insects that at present cannot be classified definitely in any of the ecological groups used in this outline. Nine of these species are ants that have been recorded as doing slight damage to corn. They are mainly associated with the different aphid species that attack corn, and the injury the ants themselves do is very slight. Many of the other species listed here have not been sufficiently studied to warrant their being placed anywhere else in the classification, their main food plants not being known. The whole group is of no present economic importance in the growing of corn.

CONCLUSION

The various species of insects recorded as corn feeders have established varying relationships with the corn plant and their other hosts. These relationships are constantly being modified and this process may be expected to continue with further environmental adjustments. Of the 352 species listed here, the 196 included in the groups below the line A-B (Plate II) may be considered for the present as doing rather slight and insignificant injury. A few species in these groups are rather commonly reported in the literature on corn insects, but the injury is unusual in occurrence and is seldom severe. It must be recognized, of course, that there is a possibility that some of these species may become more consistent corn feeders and may eventually become significant corn insects, thus passing into one of the higher groups. The probability, however, is not great as indicated by the nature of the feeding habits cited. It may be noted that there are four species listed in the definite migration group that have evolved from the plants other than grasses to corn.

Groups VI and VII contain the species that are normally grass insects. Here are included 147 forms, of which 113 are primarily grass-corn succession insects and 34 are grass-corn migrants. In

both of these groups there are some very important and destructive corn insects. They undoubtedly form the basis for the evolution of the major corn insect groups. The main path of development of these groups was probably from the original grass insects, through the grass-corn succession and grass-corn migrant groups to the group designated normally as corn insects but not dependent upon that plant for subsistence or multiplication. These later may or may not become dependent upon the corn plant, in the sense used in this discussion.

The remaining 14 species, Groups VIII and IX, are rated as being distinctly corn insects but with varying degrees of dependence upon the corn plant. As far as their main food plants are concerned they are all significant, although some are not very destructive because of biological or climatic control, or perhaps because the type of injury they cause is not of a vital nature. Of the 14 species, 7 may be regarded without much question, as having been grass insects originally. These include *Peregrinus maidis* Ashm., *Diatraea zeacolella* Dyar., *Agromyza parvicornis* Loew, *Anuraphis maidiradicis* (Forbes), *Cerodonta dorsalis* Loew, *Aphis maidis* Fitch, and *Myochrous denticollis* Say. Four other species, *Pyrausta nubilalis* Hubn., *Pleuroprucha insularia* Guen., *Diabrotica longicornis* Say, and *Diabrotica vergifera* Lec. may possibly have been grass insects but there is not much specific evidence to indicate this. One species, *Heliothis obsoleta* Fabr., no doubt fed originally on plants other than grasses, perhaps some of the *Leguminosae*, or the *Solanaceae*, or *Malvaceae*. The two remaining species, *Diabrotica soror* Lec. and *Diabrotica 12-punctata* Fabr., were undoubtedly cucurbitaceous insects.

Thus of 166 species included in the four groups of significant corn insects, 7 are undoubtedly non-grass forms, 4 others are at present of doubtful origin, while the remaining 154 are, or were at the outset, largely grass-feeding insects. It may, therefore, be concluded that corn insects are primarily and essentially grass insects, in origin.

NATURAL ECOLOGICAL CONTROL

The ultimate object of attainment in dealing with obnoxious insects is the building up of a strong environmental resistance to the species in question so that, as a result, destructive years will be the exception rather than the rule. The insect species that are native to the American Continent and have been associated with natural conditions in this country for long periods of time have

developed inter-relationships not only with their host plants but also with other insects and with bacterial and fungous diseases. A balance has thus been established between their biotic potential and the environmental resistance.

In some instances, physical factors alone are largely responsible for restraining species of insects from becoming severely destructive. The corn ear worm, *Heliothis obsoleta* Fabr., for instance, is unable to survive the winter in significant numbers in the real corn belt of the United States. Up to the present time in northwestern Ohio, the writer has been unable to rear the species through the winter successfully under natural conditions. In southern Ohio, Dr. A. E. Miller, formerly of the Ohio Experiment Station staff, found that approximately one per cent of the fall pupae were able to survive the winter. While the nature of the infestation in northern Ohio in 1926 indicated that a few individuals must have hibernated successfully, the percentage of survival was undoubtedly still lower than in southern Ohio. The destructive abundance of the species thus seems to be restricted to regions of rather mild winters.

On the other hand, many of the species, not normally destructive, would have greater probabilities of becoming severe pests if thrust into a new environment with favorable climatic conditions when these conditions are accompanied by a decrease in the biotic resistance as expressed by an abundance of preferred food and the absence of the normal parasites, predators, and diseases.

The advent of the European corn borer seems to be an illustration of this type of condition. Entering America with few if any of its original enemies, with apparently no vital change in climatic conditions, and with an extraordinarily abundant food supply, the species displayed evidence of increasing in abundance to enormous numbers. As a consequence, it was felt necessary in the corn belt country to concentrate in an effort to retard an accumulation of the species by destroying large numbers of individuals mechanically. Efforts are being made to establish a natural balance (A) by introducing forms that have developed as checks to the species in its original home, and (B) by the development of corn varieties and adjustments in cultural practices that will hinder the propagation of the species. Eventually, it is hoped that, due to a reestablished environmental resistance, the damage in normal years by this species will be light.

INDUCED ECOLOGICAL CONTROL

While natural control is the object to be desired in dealing with insects, it will always be profitable, where possible, to avoid the conditions under which injury is most likely to occur. A study of the relations the species of the different groups bear toward the corn plant reveals the type of procedure necessary for the control of the particular species. The incidental feeders ordinarily produce so trivial a damage that they may be disregarded. If injury occurs the type of control must be regulated by the reaction of the insect.

For the control of species that are normally grass feeders, grass-corn successions should be avoided, if practicable, by using intermediately another crop that is not liable to injury. If it is desired to plant corn after grass, sufficient time should be permitted to elapse after the grass has been plowed down to insure the death of all grass insects present before the corn is planted. In case of some grass-corn migrants, barriers may be established between the two crops, or the grass and corn fields may be located sufficiently far apart to prohibit migration.

In the independent group there is little that can be done in the way of modifying the environment as the species in this group have the timely characteristic of selecting their environment after the season's crop has started to develop. For the control of species that are dependent upon the corn plant the corn-corn type of crop succession should be avoided.

INSECTS THAT ATTACK CORN IN STORAGE

The insects that are specifically stored-corn species are very few in number. This can be explained perhaps by the fact that corn has not been held in storage in large amounts until very recent times. While the Indians are known to have kept corn for winter use it was only on a very small scale and probably was not practiced at all until a great many years after corn was first grown as a cultivated plant. Even after America was colonized, a long period elapsed before corn was grown so extensively that it was stored in large amounts. Because of this condition, insects would not be expected to have developed a very close adaptation to corn in storage. Although the feeding habits of insects seem rather pliable, a longer time was apparently necessary for marked specializations as stored-corn feeders. There are a number of species that attack stored corn, however, whether or not they show any

particular adaptation to it as food. Thirty-seven species are listed in this section as being stored-corn insects. In addition, a few other storage forms are included in the preceding part of this work because of first attacking the plant in the field, the primary injury occurring there.

In making a study of the food relationship of the individual species included in this section, several possible explanations for the development of the stored-corn feeding habit in insects are indicated. The writer has attempted to make a classification of the members of this group according to their feeding habits. It may be noted (Plate III) that 12 of the 37 species are always associated with other species in doing injury to corn in storage. Some of these are mainly predaceous; some saprophagous; while others feed on dead and dried animal tissues, the injury to corn being subsidiary to this. There are 20 additional species that fed originally, and still feed, on the small grains in storage. All of these have been imported from foreign countries. The remaining 5 species are native forms that apparently have developed the habit of feeding on corn in storage directly instead of first becoming adapted to other cereals. Only one of these, *Stephanopachys (Dinoderus) truncatus* Horn, may be said to prefer corn to other grains.

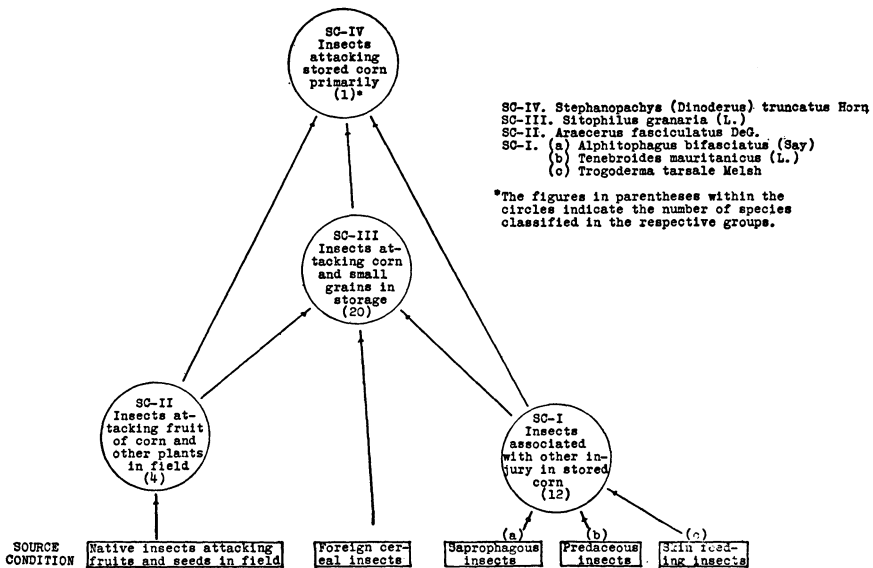


Plate III
 Diagram Showing Derivation of Stored Corn Insects

I. SPECIES ASSOCIATED WITH OTHER INJURY IN STORED CORN

(a) **Saprophagous insects.**—There are a few species, frequently found in stored corn, that normally feed on molds and other fungi. They usually attack refuse grain or that in which decay has occurred. After starting in a locally decayed area, however, the saprophagous insects of this group may increase their sphere of injury and do some damage to normal healthy grains. *Alphitophagus bifasciatus* Say, for example, is a general feeder on fungi and molds. Back and Cotton (11) bred the larvae from moist corn meal and state that the insect is often found in wet or damaged grain.

(b) **Predaceous insects.**—There are three species listed as stored-corn insects that seem to be normally predaceous. The Cadelle beetle, *Tenebroides mauritanicus* L., feeds partly on other grain-infesting insects although it also does a great amount of damage to corn. *Laemophloeus pusillus* (Schon.) is thought to be a predator on other insects or a scavenger in grain products. It is frequently found in grain in large numbers but never does severe damage. Its habits are not fully known.

(c) **Insects that attack dead animal tissue.**—There are 6 species included here that feed largely on dead and dried animal tissues, such as hairs, feathers, furs, woolen goods, and insects. *Trogoderma tarsale* Melsh., the larger cabinet beetle, is a conspicuous example of this group. It often attacks stored corn when kept for a long time. The members of this group are no doubt attracted to corn in storage by the remains of other insects and incidentally do further damage.

II. STORED-CORN INSECTS THAT ATTACK THE EARS OF CORN
AND FRUITS OF OTHER PLANTS IN FIELD

This group is of especial interest because the species included seem to show a direct trend of adaptation toward stored corn as food material. There is thus an indication of what may have been the path of evolution in the development not only of stored-corn insects but also of other stored-grain species, since some of the imported species display the same habits as do these.

An example of this group is the broad-nosed grain weevil, *Caulophilus latinasus* Say. It is apparently a Neo-tropical species that has spread over the southern part of the United States. The adult flies to corn fields and infests grain before it is fully hardened. Whole grain that is completely dried seems to be immune from the attack of this weevil. Another and similar

species is the coffee bean weevil, *Araecerus fasciculatus* DeG. It frequently attacks exposed and damaged ears in the corn fields of the South. It continues to attack corn when placed in storage but does little further damage because of the hardness of the kernels. It feeds on the fruits, seed pods, and seeds of an almost endless variety of plants.

All of the species included in this group are thought to be native to the American Continent. They are mainly tropical species that may have been associated with the corn grown and stored by the Aztecs of Mexico, the Mayas of Yucatan, or the Incas of Peru. They seem to have fed originally upon edible tubers and roots, and upon seeds and seed pods. In accordance with feeding habits of this nature, they evidently came to feed upon ears of corn in the field. When these ears were removed and placed in storage the insects continued to feed as long as the kernels were sufficiently soft. Later those species having mouth parts which were fitted for chewing hard substances might have gradually developed the habit of feeding on corn in storage, even when the kernels were mature and hard.

III. INSECTS ORIGINALLY SMALL-GRAIN FEEDERS THAT NOW ATTACK CORN AND OTHER CEREALS IN STORAGE

Foreign cereal insects form the most important source of the pests attacking stored corn. Nearly all of the more injurious insects that attack corn in storage were pests of the small grains before corn was known to civilization. All of the species included in this list are exotic forms that have been imported into America. The fact that they are not native indicates that they did not develop primarily as corn insects. Many of these insects have attacked wheat and other cereals for long periods of time. Some have become very important as feeders on corn in storage. This habit must be considered as rather recent, however, and may be said to show no especial adaptation to corn.

As illustrations of this group may be mentioned the granary weevil, *Sitophilus (Calandra) granarius* (L.), and the rice weevil, *Sitophilus oryza* (L.). The latter species is most abundant in warm countries and does a great deal of damage to stored corn in the southern United States. The adults fly to the fields to start the infestation which is continued in storage. *Sitophilus granarius* (L.), on the other hand, is a more temperate form. It is one of the oldest known species of insect pests and is very highly specialized as a stored-grain insect. This is shown by the fact that it has

lost its wings and can no longer infest grain in the field as many of the stored-grain species do. The loss of wings had undoubtedly occurred long before the species had fed on corn, the adaptation probably coming as a result of association with wheat in storage in Europe or Egypt.

IV. INSECTS THAT ATTACK STORED CORN PRIMARILY

There is not one single species of stored-grain insects that is specifically a corn-feeding species or is limited to corn for food material. The writer feels, however, that there should be such a group designated in order to make the succession chart complete. Accordingly, the larger grain borer, *Stephanopachys (Dinoderus) truncatus* Horn, is placed in this group as most nearly typifying the primary stored-corn insect. It feeds on various roots and tubers in addition to corn but seems to prefer corn to all other cereals. The species is native to tropical America and may have developed the corn-feeding habit as a result of rather long association with corn.

It may be noted that the stored-corn species native to this continent are few in number and do not show the adaptation to corn in storage that foreign species do to other cereals. This is no doubt due in part to the fact that corn has not been stored in large amounts for nearly so long a time as have wheat and some of the other cereals. The few species included here, however, seem to show that there has been a tendency toward the development of distinctly corn-feeding stored-grain insects in this continent as well as small-grain-feeding species in European countries.

SUMMARY

In conclusion, American stored-corn insects seem to have evolved from three distinct sources: (A) species that occur in stored corn because of their association with decay or with other live or dead insects that serve as their main food; (B) species that have come to feed on fruits and seeds in the field and have followed these into storage; (C) species introduced from foreign countries where they already were accustomed to feeding on small grains. By far the most important group commercially are the small-grain insects, none of which are in any way restricted to corn.

THE CLASSIFICATION OF INSECTS ATTACKING CORN

AS BASED UPON THEIR RELATIONSHIP TO THE CORN PLANT
AND TO OTHER FOOD PLANTS OR FOOD

(Refer to Plates II and III)

A. Plant-feeding Forms

I. Insects migrating to corn for shelter

Pyrausta ainsliei Heinr.*P. futilalis* Led.*P. penitalis* Grote

II. Corn insects originally non-phytophagous

a. Saprophagous insects that attack corn

Aphodius granarius (L.)*Aphonus tridentatus* (Say)*Ataenius cognatus* (Lec.)*Brachytarsus sticticus* Boh. (*B. variegatus* Say)*Chaetopsis aenea* Wied.*Colopterus (Colastus) semitectus* (Say)*Cotinis (Allorhina) nitida* (L.)*C. texana* Csy. (*Allorhina mutabilis* Gory)*Hylemyia cilicrura* Rond. (*Phorbia fusciceps*
Zett.)*Onthophagus hecate* Panz.*Phalacrus politus* Melsh.*Pyroderces (Batrachedra) rileyi* Wals.

b. Predaceous insects that attack corn

Abacidus (Pterostichus) permundus (Say)*Agonoderus comma* (Fabr.) (*A. pallipes* Say)*Anadaptus baltimorensis* (Say)*Celia (Amara) musculus* (Say)*Ceratomegilla fuscilabris* (Muls.) (*Megilla*
maculata DeG.)*Clivina impressifrons* Lec.*Coccinella novemnotata* Hbst.*Oecanthus latipennis* Riley*O. nigricornis* F. Walker*O. quadripunctatus* Beuten.*Omophron labiatum* (Fabr.)*Platynus cincticollis* (Say)*P. crenistriatus* Lec.*Poecilus (Pterostichus) lucublandus* Say*Toxomerus (Mesogramma) politus* Say*Triphleps insidiosus* Say*Triplectrus (Anisodactylus) rusticus* (Say)

III. Incidental corn-feeding insects that normally feed on plants other than grasses

- a. Legume-feeding insects
Cerotoma trifurcata (Forst)
Epilachna corrupta Muls.
Hypera punctata Fabr.
Macrosiphum trifolii Perg.
Nomophila noctuella D. & S.
- b. Weed insects
Acanolonia (Chlorochroa) conica (Say)
Acronycta oblongata S. & A.
Ametastegia glabrata (Fall.)
Anthothrips verbasci Osborn
Apantesis arge Dru.
Epicauta cinerea var. *marginata* (Fabr.)
E. pennsylvanica (DeG.)
E. vittata Fabr.
Hesperotettix speciosus Scudd.
Lixus concavus Say
L. mucidus Lec.
Lygaeus kalmii Stal.
Myzus achyrantes (Monell)
Nysius ericae (Schill.)
Psylliodes punctulata Melsh.
Sphragisticus nebulosus (Fall.)
Systema hudsonias (Forst)
S. pallicornis Schffr. (*S. frontalis* Fabr.)
S. taeniata (Say) (*S. blanda* Mels.)
Thyreocoris (Corimelaena) pulicarius (Germ.)
Xylophanes pluto Fabr. (*Thyretra tersa* L.)
- c. Garden and truck crop insects
Brachyrhinus (Otiiorhynchus) ovatus (L.)
Brevicoryne brassicae (L.)
Ceramica (Mamestra) picta Har.
Chaetocnema confinis Cr.
Chelymorphia cassidea (Fabr.) (*C. argus* Licht)
Diabrotica balteata Lec.
D. duodecimpunctata var. *tenella* Lec.
D. trivittata (Mann.)
D. vittata (Fabr.)
Epicaerus imbricatus Say
Epitrix cucumeris Har.

Euxoa tessellata Har.
Gortyna micacea Esp.
Halticus citri Ashm.
Leptoglossus oppositus Say
L. phyllopus (L.)
Ligyris gibbosus (DeG.)
Lycophotia (Peridroma) margaritosa saucia
 Hubn.

Murgantia histrionica (Hahn.)
Phyllotreta pusilla Horn.

d. Tree and shrub insects

Achatodes zeae Har.
Automeris io Fabr.
Cacoecia rosaceana Har.
Halisidota tessellaris S. & A.
Hemerocampa leucostigma S. & A.
Hyphantria cunea Dru.
Lina (Melasoma) lapponica (L.)
Porthetria dispar L.
Sibine stimulea Clem.

e. Flower- and sap-feeding insects

Carpophilus antiquus (Melsh.)
C. brachypterus (Say)
C. dimidiatus (Fabr.)
C. hemipterus (L.)
C. pallipennis (Say)
Cartodere ruficollis Marsh
Cryptarcha ampla Er.
Diabrotica atripennis (Say)
Euphoria inda (L.)
E. nitens Csy.
E. sepulchralis (Fabr.)
Glischrochilus fasciatus (Oliv.) (*Ips quadri-*
guttatus Fabr.)
Halictus lerouxii Lep.
Luperodes varicornis Lec. (*L. brunneus* Cr.)
Oecanthus latipennis Riley
O. nigricornis F. Walk.
O. quadripunctatus Beuten.
Stilbus (Eustilbus) apicalis (Melsh.)

f. General plant feeders

Acrosternum (Nezara) hilaris (Say)
Adelphocoris (Calocoris) rapidus Say

Agallia quadripunctata Prov.
Chlorochroa (Pentatoma) uhleri Stal.
Diacrisia virginica Fabr.
Empoasca fabae Har. (*E. mali* LeB.)
Epagoge sulfureana Clem.
Estigmene acraea Dru.
Eulia velutinana Walk.
Euxoa ochregaster Guen.
Gryllus assimilis (Fabr.)
G. pennsylvanicus Burm.
Isia isabella S. & A.
Lygus pratensis L.
Macroductylus subspinosus (Fabr.)
Melanoplus differentialis Thos.
Myzus persicae Sulz. (*Rhopalosiphum dianthi*
 Schrank)
Nemobius fasciatus DeG.
Nezara viridula L.
Ormensis pruinosa Say
Pemphigus lactucae (Fitch) (*Tychea brevi-*
cornis Hart)
Plagiognathus obscurus Uhl.
Poecilocapsus lineatus Fabr.
Sparganothis (Platynota) flavedana Clem.

IV. Grass insects incidental on corn

Aeolothrips bicolor Hinds
A. floridensis Watson
Anaphothrips striatus Osborn
Ancyloxypha numitor Fabr.
Apantesis phalerata Har.
Celama (Nola) sorghiella Riley
Chaetocnema pulicaria Melsh.
Cicadella similis Walk.
Cicadula sexnotata Fall.
Draeculacephala mollipes (Say)
Frankliniella (Euthrips) nervosa (Uzel.)
F. tritici Fitch
Lerema accius S. & A.
Liburniella (Liburnia) ornata (Stal.)
Macrosiphum granarium Kirby (*M. granaria* Buckt.)
Oliarus humilis (Say)
Phlepsius irroratus (Say)
Plesiothrips (Thrips) perplexus (Beach)

Solubea (Oebalus) pugnax (Fabr.)

Thyanta custator (Fabr.)

T. predator (Fabr.)

V. Migrants from plants other than grasses to corn

Barathra configurata Wlk.

Laphygma exigua var. *flavimaculata* Harvey

Loxostege similalis Guen.

L. sticticalis L.

VI. Grass-corn succession insects

Acrolophus (Pseudanaphora) arcanella Clem.

A. (Hypoclopus) mortipenellus Grote

A. (Anaphora) popeanellus Clem.

Aeolus dorsalis (Say) (*Drasterius elegans* Fabr.)

Agrotis (Noctua) c-nigrum L.

A. unicolor Walk. (*Noctua clandestina* Har.)

A. ypsilon Rott.

Anoeci querci (Fitch) (*Schizoneura panicola* Thos.)

Anomala kansana H. & McC.

A. undulata Melsh.

Apamea nictitans americana Speyer

Calendra (Sphenophorus) aequalis (Gyll.)

C. callosus (Oliv.)

C. cariosus (Oliv.)

C. compressirostris (Say)

C. destructor (Chitt.)

C. maidis (Chitt.)

C. ochreus (Lec.)

C. parvulus (Gyll.)

C. pertinax (Oliv.)

C. robustus (Horn)

C. scoparius (Horn)

C. venatus (Say)

C. zae (Walsh)

Chaetocnema denticulata (Ill.)

C. ectypa Horn

Cirphis (Heliophila) pseudargyria Guen.

Colaspis brunnea (Fabr.)

Colopha ulmicola (Fitch) (*Rhizobius spicatus* Hart)

Crambus calignosellus Clem.

C. leachellus Zinck.

C. luteolellus Clem.

C. mutabilis Clem.

- C. praefectellus* Zinck.
C. teterrellus Zinck.
C. trisectus Walk.
C. vulgivagellus Clem.
C. zeelus Fernald
Cryptohypnus abbreviatus (Say)
Diatraea grandiosella Dyar
D. saccharalis crambidoides Grote
Elasmopalpus lignosellus Zell.
Eleodes hispilabris (Say) var. *laevis* Blais.
E. letcheri vandykei Blais.
E. nigrina Lec.
E. obscura (Say) var. *sulcipennis* Mann.
E. opaca (Say)
E. pimelioides Mann.
E. suturalis (Say)
E. tricostata (Say)
Embaphion muricatum Say
Euetheola (Ligyryus) rugiceps (Lec.)
Euxoa messoria Har.
Feltia annexa Treitschke
F. gladiara Morr.
F. subgothica Haw.
Forda formicaria Heyden (*F. occidentalis* Hart)
Geoica squamosa Hart
Geraeus (Centrinus) penicellus (Herbst)
Horistonotus uhleri Horn
Hysteronевра (Aphis) setariae (Thos.)
Laphygma frugiperda A. & S.
Limonius confusus Lec.
Ludius (Corymbites) inflatus (Say)
Luperina (Hadena) stipata (Morr.)
Melanotus communis (Gyll.)
M. fissilis (Say)
M. cribulosus (Lec.)
M. infaustus (Lec.)
M. pilosus Blatch.
Meropleon cosmion Dyar
Monocrepidius bellus (Say)
M. lividus (DeG.)
M. vespertinus (Fabr.)
Neleucania (Heliophila) albilinea Hubn.

- Nephelodes emmedonia* Cram. (*N. minians* Guen.)
Ochrosidia (*Cyclocephala*) *immaculata* (Oliv.)
Oligia (*Hadena*) *fractilinea* Grote
O. misera Grote
O. semicana Wlk.
Pheletes (*Limonius*) *californicus* (Mann.)
Phyllophaga (*Lachnosterna*) *crassissima* (Blanch)
P. farcta Lec.
P. fusca (Froelich)
P. futilis Lec. (*Lachnosterna gibbosa* Burm.)
P. hirticula (Knoch.)
P. ilicis (Knoch.)
P. implicita Horn
P. inversa Horn
P. lanceolata (Say)
P. rubiginosa Lec.
P. rugosa (Melsh.)
P. tristis (Fabr.)
Polia (*Mamestra*) *renigera* Steph.
P. subjuncta Grote and Robinson
Popillia japonica Newn.
Porosagrotis orthogonia Morr.
P. vetusta Walk.
Prionus imbricornis (L.)
P. laticollis (Dru.)
Prodenia dolichos Fabr. (*P. commelinae* A. & S.)
P. eudioptera Guen.
P. ornithogalli Guen.
Pseudococcus (*Dactylopius*) *sorghiiellus* (Forbes)
Psylliodes convexior Lec.
Rhopalosiphum prunifolium (Fitch) (*Siphocoryne*
avenae Fabr.)
Sciara sp.
Septis (*Hadena*) *arctica* Boisd.
S. lignicolor Guen.
Sidemia (*Hadena*) *devastator* Brace
Sipha (*Chaitophorus*) *flava* (Forbes)
Tipula costalis Say
Toxoptera graminum Rond.
- VII. Grass-corn migrants
- Anabrus simplex* Hald.
Blissus leucopterus (Say)

- B. occiduus* Barber
Boopedon nubilum Say
Brachystola magna Gir.
Camnula pellucida Scudd.
Campylacantha olivacea Scudd.
Chorizagrotis agrestis Grote
Cirphis (Heliophila) unipuncta Haw.
C. latiuscula H. Schf.
Conocephalus brevipennis (Scudd.)
C. fasciatus (DeG.)
C. nemoralis (Scudd.)
C. (Xiphidium) strictus (Scudd.)
Deltacephalus balli Van D. (*D. nigrifrons* Van D.)
D. inimicus (Say)
Dichromorpha viridis (Scudd.)
Dissosteira carolina (L.)
D. longipennis Thos.
Melanoplus atlantis Riley
M. bivittatus (Say)
M. femur-rubrum DeG.
M. scudderi Uhl.
M. spretus Uhl.
Mocis repanda Fabr.
Oedalonotus enigma Scudd.
Orchelimum agile (DeG.) (*O. silvaticum* McNeill)
O. glaberrimum Burm.
O. vulgare Har.
Papaipema cataphracta Grt.
P. nitella Guen.
Romalea microptera Beauvois (*Dictyophorus reticulatus* Thumb)
Schistocerca alutacea Har.
S. americana (Dru.)
- VIII. Insects feeding largely upon corn but not dependent upon it for food
- Agromyza parvicornis* Loew
Anuraphis (Aphis) maidiradicis (Forbes)
Aphis maidis Fitch
Cerodonta (Ceratomyza) dorsalis Loew
Diabrotica duodecimpunctata (Fabr.)
D. soror Lec.
Heliothis obsoleta Fabr.

- Pleuroprucha insularia* Guen.
Pyrausta nubilalis Hubn. (New England "strain")
- IX. Insects dependent upon corn, at least for multiplication to great numbers
Diabrotica longicornis (Say)
D. vergifera Lec.
Diatraea zeacollella Dyar
Myochrous denticollis (Say)
Peregrinus (Dicranotropis) maidis Ashm.
Pyrausta nubilalis Hubn. (Lake Erie "strain")
- O. Unclassified, incidental, corn-feeding insects
Anthicus cervinus Laf.
Anthothrips floridensis Watson
A. niger Osborn
Apantesis phyllira Dru.
Aphanus umbrosus (Dist.) (*Microtoma atrata* Goeze)
Atomaria (Anchicera) ephippiata Zim.
Atta mexicana F. Smith (*A. fervens* Say)
Baris scolopacea Germ.
Chaetocnema parcepunctata Cr.
Cremastocheilus knochi Lec.
Diapheromera velii Walsh
Diastata sp.
Emphytina tener (Fall.)
Epizeuxis aemula Hubn.
Eubaphe aurantiaca rubicundaria Hubn. (*E. rosa* French)
Euschistus euschistoides (Voll.) (*E. fissilis* Uhl.)
E. servus (Say)
E. variolarius (P. B.)
Formica pallidifulva subsp. *achaufussi* Emery
Galgupha atra Am. and Serv.
Glyptina brunnea Horn
Helotropha reniformis atra Grote
Lasius niger L. var. *americanus* Emery
Leptodyctia plana Heid. (*L. tabida* Schaeffer)
Leucotermes sp.
Ligyrocoris diffusus (Uhl.)
Limnobaris deplanata Csy.
Melanophthalma distinguenda Com.
Monomorium minimum Buckley (*M. minutum* Mayr)
M. pharaonis L.

Myrmica scabrinodis subsp. *schencke* Emery
Oncometopia undata Fabr.
Orthaltica copalina (Fabr.)
Pogonomyrmex barbatus F. Smith
Prenolepis imparis Say
Scudderia furcata Brun.
S. pistillata Brun.
S. texensis Saus-Pict
Solenopsis molesta Say
Tortrix clemensiana Fernald

B. Grain-feeding Forms

SC-I. Insects associated with previous injury in stored corn

a. Saprophagous insects

Alphitobius piceous (Oliv.)
Alphitophagus bifasciatus (Say)
Cathartus advena (Waltl.)

b. Predaceous insects

Laemophloeus (Cryptolestes) pusillus (Schon.)
Tenebroides corticalis (Melsh.)
T. mauritanicus (L.)

c. Insects feeding on dead animal tissue

Anthrenus museorum (L.)
A. verbasci (L.)
Attagenus piceus Oliv.
Troctes divinatoria Mull.
Trogoderma ornata Say
T. tarsale Melsh.

SC-II. Insects attacking fruit of corn and other plants in field

Aracaerus fasciculatus (DeG.)
Caulophilus latinasus (Say)
Lasioderma serricorne (Fabr.)
Pharaxonotha kirschi Reit.

SC-III. Insects attacking corn and small grains in storage

Ephestia kuehniella Zell.
Gnathocerus cornutus (Fabr.)
G. maxillosus (Fabr.)
Latheticus oryzae Waterh.
Lophocateres pusillus (Klug.)
Oryzaephilus (Silvanus) surinamensis (L.)
Palorus ratzeburgi Wissm.
Plodia interpunctella Hubn.
Pyralis farinalis L.

Rhizopertha dominica (Fabr.)
Silvanus gemellatus Duv.
Sitodrepa panicea (L.)
Sitophilus (Calandra) granarius (L.)
S. oryza (L.)
Sitotroga cerealella Oliv.
Tenebrio molitor L.
T. obscurus Fabr.
Tinea granella L.
Tribolium confusum Duv.
T. ferrugineum (Fabr.)

SC-IV. Insects attacking stored corn primarily
Stephanopachys (Dinoderus) truncatus Horn

ANNOTATED LIST OF CORN INSECTS

Below is given a list of the recorded corn-feeding insects, classified to order and partially to family, together with a citation of the record of injury to corn if unusual, the nature of the injury caused by the species, an indication of its original feeding habits, and the number of the group in which it is classified in this bulletin. The plant-feeding and stored-grain insects are included in the same list. Of the 389 species recorded 166 are Coleoptera and 97 are Lepidoptera, the remainder being divided among the other orders.

ORTHOPTERA

Thirty-six species of this order are included here as having been reported to feed upon corn. The most important corn-insect members of the group are the grasshoppers which ordinarily breed in grasslands and hence get into corn by migration from their breeding grounds. Aside from the grasshoppers the insects in this order are of but little importance as corn feeders.

I. *Phasmidae*

Diaperomera velii Walsh, the prairie walking stick, group O, is reported by Gillette (69) as being abundant in Colorado on two occasions, once on corn, and once on grass. It lives normally in weedy open situations.

II. *Acrididae*

Dichromorpha viridis (Scudd.), group VII, is recorded as feeding on corn leaves in Illinois in the fall (59). It frequents "especially the vicinity of the coarse grasses which grow along the

margins of lakes, ponds, and other wet places" (15). *Camnula pellucida* Scudd., group VII, breeds in dry grassy pastures and meadows and frequently destroys considerable areas of corn and other crops. It extends across the northern part of the continent (59). *Dissosteira carolina* (L.), the Carolina grasshopper, group VII, is known to injure seriously corn and other crops (164). It is distributed throughout the United States. *D. longipennis* Thos., group VII, breeds mainly in the Rocky Mountains and migrates occasionally into the states immediately bordering the mountains on the east where it feeds on various crops, including corn (146). *Romalea microptera* Beauvois (*Dictyophorus reticulatus* Thumb), group VII, is especially injurious in the newly reclaimed regions of Florida where it attacks corn and other crops (164). *Schistocerca alutacea* Harr., group VII, lives in marshy regions amid rank grasses and feeds freely on the foliage of corn. Distributed from New England to California, especially in south portions (59). *S. americana* (Dru.), group VII, is included in Forbes' list of corn insects (59). Distributed over the United States east of the Great Plains and south of the fortieth degree of latitude (15). *Campylacantha olivacea* (Scudd.), group VII, occurs on sandy grasslands of the southern states where it attacks wheat and corn in the fall (59). *Hesperotettix speciosus* Scudd., group III (b), feeds mainly on weeds but is recorded as doing some damage to growing crops. It occurs from Montana south to New Mexico and east as far as Illinois (59). *Melanoplus atlantis* Riley, known as the lesser migratory locust, group VII, is a very general feeder attacking corn and other crops (86). It is mainly injurious west of the Mississippi River. *M. bivittatus* (Say), the two-striped grasshopper, group VII, is injurious to many important crops, including corn. It is widely distributed over the United States, except in the southeastern part. *M. differentialis* Thos., the differential grasshopper, group III (f), breeds mainly in cultivated fields instead of grasslands and has thus been aided by civilization. It has only become destructive since the settlement of its original home (15). It is most injurious in the Mississippi valley. *M. femur-rubrum* DeG., the red-legged grasshopper, group VII, is widely distributed throughout the United States and is known to injure practically all kinds of cereal and forage crops, including corn. *M. scudderi* Uhl., group VII, recorded as feeding on corn (59), occurs over the eastern part of the United States as far west as the Great Plains. *M. spretus* Uhl., the Rocky Mountain grasshopper, group VII, breeds on the eastern slopes of the Rockies and migrates to the

lower and more fertile regions. Eggs are usually deposited in dry compact areas such as meadows and pastures. *Brachystola magna* Gir., the Lubber grasshopper, group VII, occurs in semi-arid regions of the Southwest and has been known to injure corn, kafir, alfalfa, and grasses. Eggs are probably deposited in grasslands (135). *Oedalonotus enigma* Scudd., group VII, a California species that attacks all kinds of cultivated and uncultivated crops (49).

III. Tettigoniidae

Boopedon nubilum Say, group VII, is reported by Gillette (69) as occurring in grasslands along river valleys and as being taken in fields of wheat and corn. Occurs on eastern slope of Rocky Mountains. *Scudderia furcata* Brun., *S. pistillata* Brun., and *S. texensis* Saus-Pict., group O, are three species of katydids that occasionally occur on corn in Illinois. They live normally in tall grasses and weeds and are commonly taken in bushes (59). *Orchelimum agile* (DeG.) (*O. silvaticum* McNeill), *O. glaberrimum* Burm., and *O. vulgare* Harr., group VII, commonly known as large meadow grasshoppers, occur most frequently in meadows and pastures and migrate from regions of this type to corn fields (59). *Conocephalus brevipennis* (Scudd.), *C. fasciatus* (DeG.), *C. (Xiphidium) strictus* Scudd., and *C. nemoralis* (Scudd.), group VII, known as the smaller meadow grasshoppers, are reported as being frequently taken on corn in the fall in Illinois where they feed on the leaves, husks, and even the grain in the ear. Eggs are usually deposited in the stems of grasses (59). *Anabrus simplex* Hald., group VII, is a migrating species that caused immense losses to the early settlers of the interior valleys of the Rocky Mountains (117).

IV. Gryllidae

Nemobius fasciatus DeG., group III (f), is frequently found in corn fields feeding on corn ears that have fallen. It occurs commonly across the United States as far south as Georgia, Tennessee, and New Mexico. *Gryllus pennsylvanicus* Burm., group III (f), a general feeder that is quite commonly found in corn fields in Ohio where it attacks fallen ears, and sometimes eats holes through the enveloping husks. *Gryllus assimilis* Fabr., group III (f), feeds on a great variety of vegetable foods including kernels of corn and other cereals (141). The vegetable food is sometimes supplemented by the flesh and viscera of animals. *Oecanthus lati-*

pennis Riley, *O. nigricornis* F. Walker, and *O. quadripunctatus* Beuten. are included in each of the two groups, II (b) and III (e), as they are predaceous on plant lice but also feed on flowers. They attack the pollen of corn as well as the flowers of other plants. *O. nigricornis* and *O. quadripunctatus* were taken by the writer on corn in northern Ohio. All three species occur in Forbes' corn-insect list.

ISOPTERA

Leucotermes sp., group O. Termites ordinarily feed on foundation timbers and the woodwork of buildings but in a few instances have been observed to feed upon growing plants, including corn. The injury to corn consists in almost completely hollowing out the interior of the stalk, the work originating below the ground surface. Injury of this kind usually occurs on lands that have been recently cleared and have a considerable amount of decaying wood or humus in the soil (150).

CORRODENTIA

Troctes divinatoria Mull., the book louse, group SC-I (c). The Psocids are almost omnivorous, feeding on dry, dead organic matter, both plant and animal, and are frequently found in grain (11).

THYSANOPTERA

Anaphothrips striatus Osborn, group IV, a grass species that is reported to have injured corn in Connecticut (16). *Anthothrips floridensis* Watson, group O, taken on corn in Florida (165). *A. niger* Osborn, group O, recorded as occurring on corn and on a number of other plants (165). *A. verbasci* Osborn, known as the mullein thrips, group III (b), was taken on corn in Florida (165). *Aeolothrips bicolor* Hinds, the black and white cereal thrips, and *A. floridensis* Watson, group IV, were taken on corn, oats, and a few other plants in Florida (165). *Frankliniella (Euthrips) nervosa* (Uzel.), group IV, was taken quite commonly under leaf sheaths of corn in northern Ohio in October, 1925. *F. tritici* (Fitch), the flower thrips, group IV, occurs abundantly in the silk, under the leaf sheaths, and at the bases of the tassels of corn in Illinois (59). *Plesiothrips (Thrips) perplexus* (Beach), group IV, has been taken on grasses in Florida (165). The species was originally described from specimens taken on corn and other plants.

HEMIPTERA-HOMOPTERA

The Homoptera are of little importance as corn insects. Thirty-one species are included in this paper but only two or three can be considered as causing significant economic loss.

I. *Fulgoridae*

Oliarus humilus (Say), group IV, was taken on corn a number of times in northern Ohio during July and August 1925. The species occurs mainly in old pastures and meadows. *Acanolonia* (*Chlorochroa*) *conica* (Say), group III (b), feeds by preference on the hop plant but is recorded as occurring rather abundantly on corn in Illinois (59). *Ormensis pruinosa* Say, group III (f), a rather general feeder, recorded as occurring on corn in Illinois (59). Occurs in eastern United States. *Liburniella* (*Liburnia*) *ornata* (Stal.), group IV, a grass- and weed-feeding insect reported to feed on corn in Illinois (59). *Peregrinus* (*Dicranotropis*) *maidis* Ashm., the corn lantern-fly, group IX, is a tropical or subtropical form that becomes a severe enemy to late planted corn in Florida (166).

II. *Cicadellidae*

Agallia quadripunctata Prov., group III (f), a rather general feeder recorded as being somewhat injurious to corn in Illinois (59). *Oncometopia undata* Fabr., group O, is said to be common in old pastures on New England aster and is recorded as feeding on corn in Illinois (59). *Draeculacephala mollipes* (Say), group IV, feeds mainly on grasses and grains, including corn. Occurs throughout the United States (68). *Deltocephalus balli* Van D. (*D. nigrifrons* Van D.) and *D. inimicus* (Say), group VII, are very important grass and grain insects that may migrate when necessary for survival (121). They occur over a large part of the country and are recorded as injurious to corn in Illinois (59). *Phlepsius irroratus* (Say), group IV, common throughout the country in pastures and meadows and taken on corn in Illinois (59). *Cicadula sexnotata* Fall., the six-spotted leafhopper, group IV, taken frequently on corn in northwestern Ohio during the summer of 1925. It is a common species on grains and grasses, especially timothy (122). *Empoasca fabae* Harr., (*E. mali* LeB.), the apple leafhopper, group III (f), is said to be particularly injurious to late planted corn in Florida (166). It is widely distributed throughout the United States. *Cicadella similis* Walker, group IV, breeds in sugar cane in Cuba but also feeds on corn and other grasses (157).

III. *Aphididae*

Anoecia querci (Fitch) (*Schizoneura panicola* Thos.), group VI, lives largely on the roots of perennial grasses and is sometimes found in cultivated fields after sod. Recorded as occasionally occurring on corn (56). *Sipha flava* (Forbes) (*Chaitophorus flavus* Forbes), the sorghum aphid, group VI, is normally a grass-feeding species that has been recorded as occurring on corn in Illinois (59). *Aphis maidis* Fitch, the corn-leaf aphid, group VIII, feeds upon a number of plants mainly of the grass family. Its relation to corn is not definitely known but it is included here as an independent corn insect because it feeds commonly on corn, sorghums, and other grasses. It is seen quite frequently on corn in Ohio, usually in the unfolding tassel, but also in the ear and back of the leaf sheath. *Anuraphis* (*Aphis*) *maidiradicis* (Forbes), known as the corn-root aphid, group VIII, attacks the roots of corn and a number of weed hosts. *Brevicoryne brassicae* (L.), the cabbage aphid, group III (c), feeds normally on cruciferous plants, but specimens in the Ohio Experiment Station collection were taken on a corn tassel at Columbus, Ohio, October 10, 1889, by C. M. Weed. *Rhopalosiphum prunifolium* (Fitch) (*Siphocoryne avenae* Fabr.), the apple-grain aphid, group VI, occurs primarily on the roots of grains and various grasses during the summer. Taken on corn in Illinois (59). *Toxoptera graminum* Rond., group VI, feeds on a variety of grasses and cereals, including corn. It is most injurious in the southern states (176). *Myzus persicae* Sulz. (*Rhopalosiphum dianthi* Schrank), the green peach aphid, group III (f), a general feeder recorded as feeding on corn in a greenhouse in Nebraska (182). It is an introduced species. *Myzus achyranthes* (Monell), group III (b), seems to have fed originally on a number of weeds such as *Amaranthus* spp. It was recorded as being taken in abundance on leaves of corn in Illinois (57). *Macrosiphum trifolii* Perg., group III (a), a clover species found in colonies on leaves of corn in Illinois (59). *M. granarium* (Kirby) (*M. granaria* Buckt), the English grain aphid, group IV, a grass and cereal aphid that has been taken from corn leaves in Illinois (59). *Colopha ulmicola* (Fitch) (*Rhizobius spicatus* Hart), group VI, a grass root aphid occasionally found on the roots of corn (56). *Hysteroneura* (*Aphis*) *setariae* (Thos.), group VI, a grass-root-feeding species recorded as occurring rather sparingly on corn near Ames, Iowa (177). *Forda formicaria* Heyden (*F. occidentalis* Hart), group VI, a grass-root-feeding species recorded as occurring on corn in Illinois (56). *Geoica squamosa*

Hart, group VI, found on roots of corn in fields that had been in grass the previous year (56). *Pemphigus lactucae* (Fitch) (*Tychea brevicornis* Hart), group III (f), occurs on the roots of a variety of plants (43). Recorded as being found on the roots of corn in Illinois (56).

IV. Coccidae

Pseudococcus (Dactylopius) sorghiellus (Forbes), the sorghum mealy bug, group VI, commonly found infesting the roots of corn planted on sod in Illinois (56).

HEMIPTERA-HETEROPTERA

In this order are included twenty-eight species that have been recorded as attacking the corn plant. With the exception of the chinch bug, *Blissus leucopterus* Say, they are of but little economic importance as corn insects.

I. Miridae

Plagiognathus obscurus Uhl., group III (f), a general feeder recorded as feeding on the kernels at the tips of the ears of corn, in Illinois (59). Distribution—east of the Rocky Mountains. *Lygus pratensis* L., the tarnished plant bug, group III (f), a general feeder commonly taken on the corn plant but not often recorded as seriously injurious. Occurs throughout the United States. *Adelphocoris (Calocoris) rapidus* Say, group III (f), a general feeder commonly taken at the tips of the ears of corn. Widely distributed over the United States. *Poecilocapsus lineatus* Fabr., group III (f), included in Forbes' list of corn insects (59) by virtue of an old report by Fletcher that it feeds on young sweet corn kernels. It is a general feeder and is widely distributed east of the Rocky Mountains. *Halticus citri* Ashm., group III (c), generally distributed throughout eastern United States and Canada, where it feeds on a great variety of garden and field crops and weeds, a number of legumes being included among its hosts. It is recorded by Crosby and Leonard as feeding on corn (42).

II. Anthocoridae

Triphleps insidiosus Say, group II (b), a predaceous species that is found commonly in both nymphal and adult stages at the tips of ears of corn. It likely feeds on the juices of the corn plant as well as those of insects.

III. *Tingididae*

Leptodictya plana Heid. (*L. tabida* Schaeffer), group O, is said to aid the chinch bug materially in doing damage to corn in the cape region of Lower California (52). The species occurs in Oklahoma.

IV. *Lygaeidae*

Lygaeus kalmii Stal., group III (b), taken, by the writer, a number of times on corn, in one case with the beak inserted in an unripe kernel of corn. Occurs throughout the United States, mainly on milkweed. *Nysius ericae* (Schill.), the false chinch bug, group III (b), feeds almost exclusively on weeds, but in periods of dry weather attacks cultivated crops, including corn (115). *Blissus leucopterus* (Say), the chinch bug, group VII, migrates to corn from barley, wheat, and other grasses. It is widely distributed over the United States and eastern Canada. *B. occidentalis* Barber, group VII, originally described from Colorado and said to be very destructive to sugar cane and corn in the cape region of Lower California (52). *Ligyrocoris diffusus* (Uhl.), group O, taken quite commonly on corn in northwestern Ohio during July and August 1925. *Sphragisticus nebulosus* (Fall.), group III (b), said to feed preferably on lamb's-quarters, *Chenopodium album* L., but found puncturing corn leaves and causing sear brown spots (59). *Aphanus umbrosus* (Dist.) (*Microtoma atrata* Goeze), group O, taken in both adult and nymphal stages on husks and grains of corn (59).

V. *Coreidae*

Leptoglossus phyllopus (L.), the leaf-footed plant bug, group III (c), occurs most commonly in Gulf States, where it attacks truck and garden crops (166). It is included in Forbes' 1905 corn-insect list. *L. oppositus* Say, group III (c), seems to prefer the fruits of cucurbitaceous plants but is also recorded as vigorously attacking growing corn at Arlington, Virginia (32).

VI. *Pentatomidae*

Murgantia histrionica (Hahn), the Harlequin bug, group III (c), is primarily a pest of crucifers, but when these are killed attacks all kinds of truck crops, including corn. Distributed over southern United States (29). *Euschistus euschistoides* (Voll.) (*E. fissilis* Uhl.), group O, feeds on a number of plants, mainly weeds, but is recorded as attacking corn ears in Illinois (59).

E. servus (Say), group O, a southern species that has been taken on a number of hosts, including corn (118). *E. variolarius* (P. B.), group O, a common species frequently found on corn in Ohio. It is reported as attacking a great variety of plants, including corn. Widely distributed east of the Rocky Mountains. *Chlorochroa (Pentatoma) uhleri* Stal., group III (f), a general feeder that is especially destructive from South Dakota to Texas and west. Reported by Saunders (139) as being severely injurious to corn in South Dakota in 1897. *Solubea (Oebalus) pugnax* (Fabr.), group IV, a southern species that feeds on grasses and is sometimes injurious to rice. Recorded by Ashmead (10) as feeding on corn pollen in Florida. *Thyanta custator* (Fabr.), group IV, occurs on a number of grasses and weeds, and is recorded as sucking the sap from corn leaves in Illinois (59). *T. perditor* (Fabr.), group IV, reported to have seriously damaged corn, oats, and sorghum in Texas (134). *Acrosternum (Nezara) hilaris* (Say), the green stink bug, group III (f), a general feeder recorded as attacking corn along with other plants (118). *Nezara viridula* L., group III (f), a quite general feeder that is recorded as feeding on corn along with a great many other plants in the South (95).

VII. Cydnidae

Thyreocoris (Corimelaena) pulicarius (Germ.), group III (b), taken on various weeds and shrubs and recorded as frequently occurring on corn in Illinois (59). *Galgapha atra* Am. & Serv., group O, taken on corn several times during August, 1925, in northern Ohio.

COLEOPTERA

The order Coleoptera includes nearly half of the species that are recorded as feeding on corn. Twenty-one families are represented but most of the species, and practically all of the more injurious ones, are included in four families: the Scarabaeidae represented by the white grubs; the Curculionidae, by the billbugs; the Elateridae, by the wireworms; and the Chrysomelidae, by the leaf beetles, the larvae of some of which are root worms. The members of this order have various feeding habits, but the species most important as corn insects are injurious during the larval stage when they attack the roots of the plant.

I. Carabidae

Clivina impressifrons Lec., predaceous, group II (b), attacks seed corn in the ground (125). *Abacidus (Pterostichus) permundus* (Say), predaceous, group II (b), recorded as feeding on

kernels of corn in the ear (59). *Poecilus (Pterostichus) lucublandus* Say, *Celia (Amara) musculus* (Say), *Platynus cincticollis* (Say), *Platynus crenistriatus* Lec., and *Triplectrus (Anisodactylus) rusticus* (Say) are all primarily predaceous and are included in group II (b). They are recorded as feeding on ears of corn on the stalk or when fallen (59). *Anadaptus (Anisodactylus) baltimorensis* (Say) and *Agonoderus comma* (Fabr.), predaceous, group II (b), commonly attack seed corn in the ground. Distribution general in eastern United States.

II. Omophronidae

Omophron labiatum (Fabr.), ordinarily predaceous, group II (b), feeds on the seed grains and young shoots of newly planted corn in the southern states (72).

III. Meloidae

The blister beetles, *Epicauta vittata* Fabr., *E. pennsylvanica* (DeG.), and *E. cinerea* var. *marginata* (Fabr.), group III (b), are commonly found feeding on the foliage and silk of corn. They are frequently reported as being destructive to garden crops, such as potatoes and tomatoes, but seem to feed primarily on native weeds. They are especially fond of the flowers of native legumes (116).

IV. Anthicidae

Anthicus cervinus Laf., group O, taken several times in the silk of ears of corn in northwestern Ohio in 1925. Habits not well known.

V. Elateridae

Monocrepidius bellus (Say), *M. lividus* (DeG.), and *M. vespertinus* (Fabr.), group VI, are wireworms that commonly attack corn in the southern states (94). *Aeolus dorsalis* (Say) (*Drasterius elegans* Fabr.), group VI, a serious pest, in Indiana and Illinois, of corn and wheat following grass; occurs throughout northern United States (94). *Limonius confusus* Lec., group VI, is most destructive to garden crops, especially potatoes, but also attacks the roots of corn. The species breeds in grasslands. It occurs from New York to Illinois and the Lake Superior region (94). *Pheletes (Limonius) californicus* (Mann.), group VI, a meadow wireworm, is recorded as attacking corn in California (94). *Ludius (Corymbites) inflatus* (Say), group VI, is recorded as being injurious to corn at Pullman, Washington. It occurs over

most of the United States (94). *Cryptohypnus abbreviatus* (Say), group VI, is injurious to corn following grass, over the northern half of the United States (94). *Melanotus communis* (Gyll.), *M. cribulosus* (Lec.), *M. fissilis* (Say), *M. infaustus* (Lec.), and *M. pilosus* Blatch., group VI, are commonly known as the corn wireworms. They are seriously injurious in the central states of the Mississippi valley and eastward. In general, they are somewhat confined to low and poorly drained soil that is inclined to be acid. *Horistonotus uhleri* Horn, the sand wireworm, group VI, does severe damage to corn in the southern part of the United States (38, 94).

VI. Dermestidae

Attagenus piceus Oliv., the black carpet beetle, group SC-I (c), is primarily injurious to carpets, silks, woolen goods, feathers, etc., but is also known to breed in cereals (11). *Trogoderma ornata* Say, group SC-I (c), was reared from ears of popcorn by Webster and Mally (174). *Trogoderma tarsale* Melsh., group SC-I (c), is occasionally found living in grains (11). The last two species ordinarily feed on insect skins and other animal remains. *Anthrenus museorum* (L.) and *A. verbasci* (L.), group SC-I (c), are mainly museum pests but are occasionally found to infest grains and grain products (11).

VII. Ostomidae

Tenebroides corticalis (Melsh.), group SC-I (b), was reported by Glover (72) to attack corn and other grain in Maryland. *T. mauritanicus* (L.), the Cadelle beetle, group SC-I (b), is a cosmopolitan insect in flour, meal, and stored grain but is also predaceous on other grain-infesting insects. *Lophocateres pusillus* (Klug.), group SC-III, is injurious to stored corn in the southern states. It was imported in rice and cereals from Siam (11).

VIII. Nitidulidae

Colopterus (Colastus) semitectus (Say), group II (a), found on decaying corn ears in southern states (72). *Carpophilus antiquus* (Melsh.) and *C. pallipennis* (Say) are sap-feeding insects, group III (e), that attack injured kernels of corn in the field (59). *C. brachypterus* (Say), group III (e), taken by the writer at tip of ear of corn in field at Bono, Ohio, in August, 1925. *C. dimidiatus* (Fabr.), group III (e), breeds in damaged ears in corn fields in the southern states (11). *C. hemipterus* (L.), group III (e), known

as the dried-fruit beetle (50), was taken by the writer on corn at tip of ear, at Bono, Ohio, in October, 1925. *Glischrochilus fasciatus* (Oliv.) (*Ips quadriguttatus*), group III (e), a sap feeder, is commonly associated with injury caused by the European corn borer and corn ear worm where it feeds on exuding sap. In the larval stage it is said to feed on decaying vegetable material (56). Generally distributed over northern United States. *Cryptarcha ampla* Er., group III (e), a sap-feeding species, taken as larvae in stalks of corn at Marblehead, Ohio, September, 1929.

IX. Cucujidae

Oryzaephilus (Silvanus) surinamensis (L.), the saw-toothed grain beetle, SC-III, reported as doing severe damage to corn at Shelby, Ohio, in June, 1923. Cosmopolitan in distribution. *Silvanus gemellatus* Duv., group SC-III, is one of the most common beetles occurring in stored corn in the South. It also attacks exposed ears in the field (11). *Cathartus advena* (Waltl.), group SC-I (a), feeds mainly on molds developing in damp and moldy grains. Cosmopolitan in distribution. *Laemophloeus (Cryptolestes) pusillus* (Schon.), group SC-I (b), is thought to be a predator or scavenger. The species is frequently found in stored grain in the South but does little damage (11).

X. Cryptophagidae

Pharaxonotha kerschi Reit., group SC-II, introduced from Mexico, where it attacks stored corn and edible tubers (11). *Atomaria (Anchicera) ephippiata* Zimm., group O, taken by the writer at tip of corn ear at Bono, Ohio, in August, 1925.

XI. Lathridiidae

Cartodere ruficollis Marsh (*Lathridius pulicarius* Melsh.) group III (e), reported by Lintner (103) as feeding on corn following a previous injury. *Melanophthalma distinguenda* Com., group O, taken quite commonly by the writer in the silk at the tips of ears of corn in northwestern Ohio. Cosmopolitan in distribution.

XII. Phalacridae

Phalacrus politus Melsh., group II (a), feeds on smut and the pollen of corn (59). *Stilbus (Eustilbus) apicalis* (Melsh.), group III (e), occurs commonly at tips of ears and under leaf sheaths of corn in northern Ohio. Distribution general in United States.

XIII. *Coccinellidae*

Ceratomegilla fuscilabris (Muls.) (*Megilla maculata* DeG.), predaceous, group II (b). Adults reported as feeding upon exposed kernels at tips of ears of corn (59). *Coccinella novemnotata* Hbst., predaceous, group II (b), recorded as feeding on foliage of corn (59). Distribution general. *Epilachna corrupta* Muls., Mexican bean beetle, group III (a), feeds on corn when extremely abundant and when bean foliage has been destroyed (90). Distribution—southwestern and southern states as far north as Michigan and New York.

XIV. *Tenebrionidae*

Eleodes hispilabris (Say) var. *laevis* Blais., *E. letcheri vandykei* Blais., *E. nigrina* Lec., *E. obscura* (Say) var. *sulcipennis* Mann., *E. opaca* (Say), *E. pimelioides* Mann., *E. suturalis* (Say), *E. tricostata* (Say), and *Embaphion muricatum* Say, group VI, are commonly known as the "false wireworms". They do a great deal of damage to corn and other cereals in the Pacific Northwest. The comparatively recent development of these insects as pests is due largely to the fact that large areas of grazing land have been brought under cultivation. The larvae feed largely on the roots of the various grasses occurring in the native pastures and when these are replaced by other crops the damage is transferred to the new plants. They are thus grass-corn succession insects (93, 109, 162, 163). *Alphitophagus bifasciatus* (Say) and *Alphitobius piceus* (Oliv.), group SC-I (a), feed mainly on decaying vegetable matter and attack corn in storage only when damp or when started to decay (11). *Gnathocerus cornutus* (Fabr.) and *Gnathocerus maxillosus* (Fabr.), group SC-III, prefer flour and meal but attack a variety of grains. Cosmopolitan in distribution (11, 142). *Latheticus oryzae* Waterh., group SC-III. Primarily and originally a pest of other cereals but found attacking corn in Texas in 1908. Cosmopolitan in distribution (25). *Tribolium confusum* Duv., *T. ferrugineum* (Fabr.), *Tenebrio molitor* L., and *T. obscurus* Fabr., SC-III, are primarily pests of cereals other than corn. All are cosmopolitan species that have been introduced into this country. *Palorus ratzeburgi* Wissm., group SC-III, widely distributed as a pest of ground products but also found in stored grain (11).

XV. *Anobiidae*

Sitodrepa panicea (L.), group SC-III, known as drug-store beetle but also attacks cereals when stored for long periods unmolested. World wide in distribution. *Lasioderma serricorne*

(Fabr.), group SC-II, is commonly known as the cigarette beetle but may attack a variety of grains and seeds left long in storage. Generally distributed in temperate, subtropical, and tropical regions (11).

XVI. *Bostrichidae*

Rhizopertha dominica (Fabr.), group SC-III, an introduced species that does serious damage to cereals in warm climates. *Stephanopachys* (*Dinoderus*) *truncatus* Horn., the larger grain borer, group SC-IV, is a tropical species that feeds on corn in preference to other cereals but also attacks roots and tubers (24).

XVII. *Scarabaeidae*

Onthophagus hecate Panz., group II (a), attacks ears of corn when softened by dampness and decay (56). *Aphodius granarius* (L.), group II (a), a dung beetle that feeds upon seed corn in the hill (56). *Ataenius cognatus* Lec., group II (a), a dung beetle taken within husks of fallen ears of corn (59).

Phyllophaga (*Lachnosterna*) *crassissima* (Blanch.), *P. farcta* Lec., *P. fusca* (Froelich), *P. futilis* Lec. (*Lachnosterna gibbosa* Burm.), *P. hirticula* (Knoch.), *P. implicita* Horn, *P. ilicis* (Knoch.), *P. inversa* Horn, *P. lanceolata* (Say), *P. rubiginosa* Lec., *P. rugosa* (Melsh.), and *P. tristis* (Fabr.), group VI, are all species of white grubs that have been recorded as attacking the roots of corn. They are distinctly grass-feeding insects that inhabited the prairies while America was still in its native state. They ordinarily do damage to corn only when following grasses and are thus included in group VI. Since most of them have a three-year life cycle severe damage occurs once in three years (46, 56, 62, 63, 82, 160).

Macroductylus subspinosus (Fabr.), the rose chafer, group III (f), formerly fed by preference on the blossoms of the rose, but in times of great abundance attacked corn along with other plants. In recent years it has extended its range of food plants and is now practically omnivorous (35). *Anomala kansana* H. & McC., a white grub, group VI. The larvae feed on roots of corn and the adults on foliage (84). *A. undulata* Melsh., group VI, recorded as feeding, in the adult stage, on silk of corn. Larvae probably feed on roots of grasses or on decomposing vegetable matter in the soil (59). *Popillia japonica* Newm., the Japanese beetle, group VI, is another grass-feeding species. The adults attack corn along with a number of other plants (147). *Ochrosidia* (*Cyclocephala*)

immaculata (Oliv.), a white grub, group VI, injures roots of corn (59). *Euetheola* (*Ligyris*) *rugiceps* (Lec.), the sugar cane beetle, group VI, does damage to corn only when sod lands are plowed down and immediately planted to corn. Confined to southern states (127). *Ligyris gibbosus* (DeG.), the carrot beetle, group III (c), is occasionally destructive to corn in the southern states (22). *Aphonus tridentatus* (Say), group II (a), attacks corn seedlings; probably breeds in barnyard manure (59). *Cotinis* (*Allorrhina*) *nitida* (L.), the green June beetle, group II (a), breeds in manure and damages crops nearby. Larvae feed on roots of corn in seedling stage, while adults injure ears of growing corn. The species is common in the South (33). *C. texana* Csy., (*Allorrhina mutabilis*), group II (a), has feeding habits similar to *C. nitida*, but inhabits the arid Southwest (89). *Euphoria inda* (L.), *E. nitens* Csy. (*E. melancholica* Horn), and *E. sepulchralis* (Fabr.), group III (e), commonly feed on flowers and fruits and the sap of trees. They attack tassels, silk, and unripe kernels of corn (59). *Cremastocheilus knochi* Lec., group O, taken on fallen ears of corn (59).

XVIII. *Cerambycidae*

Prionus imbricornis (L.) and *P. laticollis* (Dru.), group VI. Larvae feed on roots of grass but occasionally attack corn (56).

XIX. *Chrysomelidae*

Colaspis brunnea (Fabr.), the grape colaspis, group VI, is occasionally found attacking corn rather severely in northeastern Ohio. Larva is said by Forbes to feed primarily on the roots of timothy. Generally distributed east of the Rocky Mountains (59). *Myochrous denticollis* (Say), known as southern corn leaf beetle, group IX, is injurious to corn in southern states. Injury is most likely to occur in field that has been neglected for several years previously (98). *Lina* (*Melasoma*) *lapponica* (L.), group III (d), a willow insect, recorded as attacking corn along a willow fence (59). *Cerotoma trifurcata* (Forst), the bean leaf beetle, group III (a), a legume-feeding insect recorded as destructive to corn, its native food plants being bush clover, hog peanut, and tick trefoil. Occurs throughout eastern United States (42). *Diabrotica atripennis* (Say), group III (e). Adult feeds on pollen and silk of corn (22). Larval habits unknown. *D. balteata* Lec., group III (c), a truck crop insect that is injurious to corn in Texas (104). *D. duodecimpunctata* (Fabr.), the spotted cucumber beetle, group VIII, is sometimes seriously injurious to corn in southern Ohio and

other states farther south. It completes its life cycle readily on corn and a number of other plants. *D. duodecimpunctata* var. *tenella* Lec., a truck crop insect, group III (c), is closely related to *D. duodecimpunctata* but occurs only in the extreme Southwest where it is recorded as attacking the roots of corn along with other plants (156). *D. longicornis* (Say), the corn root worm, group IX, is most injurious to corn where the crop is grown in the same field repeatedly, as in the west central states. In the larval stage it is not known to feed on any other plant. *D. soror* Lec., the western spotted cucumber beetle, group VIII, has habits similar to *D. duodecimpunctata* but occurs only along the Pacific Coast. *D. trivittata* (Mann.), group III (c), a truck crop species that is also injurious to the silk of corn along the Pacific Coast (23). *D. vergifera* Lec., group IX, occurs in Colorado and has habits almost identical with *D. longicornis* (70). *D. vittata* (Fabr.), the striped cucumber beetle, group III (c), is ordinarily a cucurbit insect, but adults are taken feeding commonly on leaves, pollen, silk, and unripe kernels of corn. *Luperodes varicornis* Lec. (*L. brunneus* Cr.), group III (e), a flower-feeding species that is said to have done much damage to the silk of corn in the southern states (75). *Epitrix cucumeris* Har., the potato flea beetle, group III (c), occasionally attacks the leaves of corn (59). *Orthaltica copalina* (Fabr.), group O, taken by writer on corn at Bono, Ohio, in July 1925. *Chaetocnema ectypa* Horn, known as the desert corn flea beetle, group VI, does considerable damage to corn and related crops. Probably fed originally on the native grasses growing in the southwestern states (187). *C. confinis* Cr., the sweet potato flea beetle, group III (c), is primarily injurious to sweet potato but is commonly found on corn in fields where bindweed is permitted to grow. *C. denticulata* (Ill.), group VI, a grass insect recorded as doing conspicuous injury to corn in Illinois (59). *C. parcepunctata* Cr., group O, reported as destructive to young corn in North Carolina. Preferred feeding habits unknown (149). *C. pulicaria* Melsh., group IV, is occasionally recorded as injurious to corn and to a few other grasses. In 1918 the species did severe injury to corn in Licking and Fairfield Counties, Ohio. Larval habits are unknown. *Systema hudsonias* (Forst.), group III (b), a weed insect that is sometimes said to injure corn. A field of corn near Akron, Ohio, was reported to have been injured by this species in July, 1922. *S. pallicornis* Schffr. (*S. frontalis* Fabr.), group III (b), a weed insect that sometimes feeds upon corn, together with a number of truck crops (80). *S. taeniata* (Say)

(*S. blanda* Mels.), the banded flea beetle, group III (b), is a weed insect that frequently does severe injury to the leaves of young corn plants in the central states. *Glyptina brunnea* Horn, group O, recorded as feeding on leaves of young corn in Illinois. Larval habits unknown (59). *Phyllotreta pusilla* Horn, group III (c). Larvae feed primarily on the roots of cruciferous vegetables. When the larvae are abundant, corn and other plants are attacked (34). *Psylliodes convexior* Lec., group VI, occurs on grasses and sedges (14). Recorded by Webster as feeding on corn leaves in Indiana (59). *P. punctulata* Melsh., group III (b), a weed insect that sometimes attacks corn (59). *Chelymormpha cassidea* (Fabr.) (*C. argus* Licht), the argus tortoise beetle, group III (c), prefers sweet potato to all other plants, but is also recorded as attacking corn (30). Was taken repeatedly on corn in northeastern Ohio in 1923.

XX. *Platystomidae*

Brachytarsus sticticus Boh. (*B. variegatus* Say), group II (a), feeds commonly on smut of wheat and corn (59). Taken repeatedly on leaves and ears of corn at Bono, Ohio, during summer of 1925. *Araecerus fasciculatus* DeG., the coffee bean weevil, group SC-II, feeds on exposed ears of corn in field and crib in southern states, also attacks fruits, seed pods, and seeds of many other plants (11).

XXI. *Curculionidae*

Epicaerus imbricatus Say, imbricated snout beetle, group III (c), attacks a number of garden crops, and occasionally does injury to corn (59). Generally distributed in United States east of Rocky Mountains, but has become rather scarce recently (31). *Brachyrhinus (Otiorrhynchus) ovatus* (L.), group III (c), a strawberry root species that occasionally feeds on roots of corn (59). *Hypera punctata* Fabr., the clover leaf weevil, group III (a), feeds primarily on the clovers and alfalfa but will also attack other plants, including corn. It is a cosmopolitan species that has been introduced into this country (102). *Lixus concavus* Say, the rhubarb curculio, and *L. mucidus* Lec., group III (b). The larvae of these two species ordinarily breed in weeds but the adults sometimes attack corn in a manner similar to that of billbugs (59). *Baris scolopacea* Germ., group O, taken by the writer on corn at Mentor, Ohio, in July, 1923. *Geraeus (Centrinus) penicellus* (Herbst), group VI, bores into upper part of corn stalk and probably attacks other large stemmed grasses (2). *Limnobaris*

deplanata Csy., group O. A beetle doubtfully identified as this species was recorded as feeding behind leaf sheath of corn (59). *Caulophilus latinasus* (Say), group SC-II, a southern species that attacks corn both in field and crib. It also feeds on other seeds and cereals (40). *Sitophilus* (*Calandra*) *granarius* (L.) and *S. oryza* (L.), group SC-III, are cosmopolitan species that have probably been associated with small grains in storage for long periods in Europe or Egypt. Both species have been severely destructive to corn in the United States, the latter being most injurious in the South (11, 39, 148).

The following members of the genus *Calendra* (*Sphenophorus*) are commonly known as the corn billbugs: *Calendra aequalis* (Gyll.), *C. callosus* (Oliv.), *C. cariosus* (Oliv.), *C. compressirostris* (Say), *C. destructor* (Chitt.), *C. maidis* (Chitt.), *C. ochreus* (Lec.), *C. parvulus* (Gyll.), *C. pertinax* (Oliv.), *C. robustus* (Horn), *C. scoparius* (Horn), *C. venatus* (Say), and *C. zaeae* (Walsh). They are included in group VI and form a splendid illustration of the reaction of grass insects toward corn. Practically all of these forms feed normally in the larval stage upon the roots and stems of grasses or grass-like plants, such as rushes, sedges, and cat-tails. They were originally inhabitants of the wet prairies. Injury to corn is limited to spring and early summer, following spring-plowing of a sod of long standing. It is thus directly the result of the thrusting of an environment of corn around the billbugs, together with a removal of their native hosts. Injury can be readily avoided by not growing corn after grass or by plowing grasslands in the fall in order that the billbugs may be starved out before corn is available (59, 81, 114, 136, 137, 138).

LEPIDOPTERA

The Lepidoptera make up the second largest order of corn-feeding insects. In this group, unlike the Coleoptera, it is only the larvae or caterpillars that do the feeding. Their food consists largely of the part of the plant above ground, namely, the leaf, stem, tassel, silk, and ear, although a few of the cutworms feed on the stem below the surface of the ground. Of the ninety-seven species included in this order forty-five are Noctuids and twenty-three are Pyralids, the remainder being scattered through a number of families.

I. *Hesperiidae*

Ancyloxypha numitor Fabr., group IV, a general grass feeder taken as a larva on corn in Lake County, Ohio, in July, 1925. *Lerema accius* S. & A., the corn leaf-tyer, group IV, has been fre-

quently recorded as feeding on corn, but other feeding records indicate that it is primarily a grass insect. The species does but slight injury to corn. It occurs in the region bordering on the coast from New England to Mexico (4).

II. *Sphingidae*

Xylophanes pluto Fabr. (*Theretra tersa* L.), group III (b), feeds mainly on plants of the Madder family but recorded as attacking corn in Illinois (59).

III. *Saturniidae*

Automeris io Fabr., group III (d), feeds largely on foliage of trees but is also taken quite frequently feeding on foliage of corn in Ohio and elsewhere.

IV. *Arctiidae*

Eubaphe aurantiaca rubicundaria Hubn. (*E. rosa* French), group O, recorded as feeding on leaves of corn in Illinois (59). *Estigmene acraea* Dru., group III (f), a general feeder that commonly attacks the silk and foliage of corn in the fall. Distribution—general throughout the United States. *Hyphantria cunea* Dru., group III (d), is primarily a pest of orchard and shade trees but a group of caterpillars of this species was taken on corn in Lake County, Ohio, in August 1925 by Mr. F. W. Poos. One individual was reared to the adult stage on corn by the writer. *Isia isabella* S. & A., group III (f), a general feeder widely distributed in the United States, is on record as being seriously injurious to young corn in Iowa (120). *Diacrisia virginica* Fabr., group III (f), is a general feeder occasionally seen feeding on leaves of corn in late summer and fall. Distribution is general. *Apantesis arge* Dru., group III (b), was recorded as being very destructive to corn in the South many years ago but its chief host is the evening primrose (59). *A. phalerata* Har., group IV, is most abundant in grasses but feeds readily on corn in confinement (59). *A. phyllira* Dru., group O, is reported to feed on corn and other low growing plants in the South (59). *Halisidota tessellaris* S. & A., group III (d), feeds ordinarily on foliage of a great many trees, but a number of caterpillars attacking the foliage of corn were taken by the writer at Geneva, Ohio, in September, 1923. *Celama (Nola) sorghiella* Riley, group IV, destructive to sorghum and kaffir corn in Kansas (83). Reported by Ashmead (10) to have been taken from tassels of corn in Florida.

V. *Noctuidae*

Acronycta obliquata S. & A., group III (b), breeds commonly on smartweed and is frequently taken on corn in Ohio and elsewhere. Distribution—east of Rocky Mountains. *Oligia (Hadena) semicana* Walk., group VI. A caterpillar doubtfully determined as this species was taken in the act of feeding on the leaves of corn in Connecticut (16). *Oligia (Hadena) fractilinea* Grote, group VI, known as the lined stalk borer, is injurious to corn in Ohio every year. Injury occurs only when corn follows a timothy sod. The species is most commonly injurious in Ohio and New York. *O. misera* Grt., group VI, destructive to corn in northern Ohio under same conditions as *O. fractilinea* (169). *Septis (Hadena) arctica* Boisd. and *S. lignicolor* Guen., group VI, are cutworms occurring in northern United States, east of the Rocky Mountains (59). *Sidemia (Hadena) devastator* Brace, group VI, known as the glassy cutworm, was one of the commonest species found in northwestern Ohio corn fields during the spring of 1925. Distribution—general, but injurious mainly in northern states. *Luperina (Hadena) stipata* (Morr.), group VI, a timothy and prairie sod species that burrows in the heart of the corn plant (48, 73). Distribution—United States east of Rocky Mountains. *Helotropha reniformis atra* Grote, group O, recorded as injuring corn in Michigan and in Manitoba, Canada. General habits unknown but species acts as a stalk borer in corn (67). *Laphygma (Caradrina) exigua* var. *flavimaculata* Harvey, the beet army worm, group V, seems to prefer sugar beets, but migrates, when abundant, to other plants, including corn. The species is cosmopolitan in distribution but in the United States occurs only in the western part (22). *Laphygma frugiperda* A. & S., group VI, is essentially a grass feeder but occasionally does considerable damage to corn especially in southern states (105). *Prodenia eudioptera* Guen., group VI, a grass-feeding species that also attacks leaves of corn (59). *P. dolichos* Fabr. (*P. commelinae* A. & S.), group VI, is listed by Sherman (143) as a corn insect in North Carolina. *P. ornithogalli* Guen., group VI, is known as cotton cutworm but is also known to injure corn from Indiana to Kansas and southward. A caterpillar of this species was taken feeding on corn at Bono, Ohio, in the summer of 1925. *Agrotis (Noctua) c-nigrum* L., the spotted cutworm, group VI, is a cutworm that is especially injurious to garden vegetables which it prefers to grasses and grains. It breeds normally in grasslands (59). *A. unicolor* Walk. (*Noctua clandestina* Har.), group VI, feeds on a number of grasses and

vegetables and is recorded by Lintner as being very destructive to corn in New York. It occurs over northern United States and is widespread in Canada (66). *A. ypsilon* Rott., group VI, breeds almost wholly in grasslands and injures corn only when following grass. World wide in distribution (59). *Lycophotia (Peridroma) margaritosa saucia* Hubn., group III (c), mainly a garden pest but occasionally does great damage to fruits and field crops and is frequently found in corn fields (59). *Chorizagrotis agrestis* Grote, group VII, is known as the western army worm and has habits similar to *Cirphis unipuncta* Haw. (49). *Feltia annexa* Treitschke, group VI, was taken occasionally in hills of corn following grass in northwestern Ohio in summer of 1925. Species also recorded as destructive to cotton and many other plants. *F. gladiaria* Morr., group VI, destructive to corn after old sod or sometimes by migration from a neighboring meadow (59). *F. subgothica* Haw., (*F. jaculifera* Guen.), group VI, a typical cutworm very injurious to young corn (59). Distributed throughout the United States.

Euxoa messoria Har., group VI, is a general feeder and is widely distributed over eastern United States and Canada. During the summer of 1925 it was very numerous in corn fields following grass in northwestern Ohio. As high as 30 per cent of the plants were taken in several fields. *E. ochregaster* Guen., group III (f), attacks almost any succulent plant and is an important pest of corn in Canada and northern United States (66). *E. tessellata* Har., group III (c), primarily a pest of garden crops but occasionally recorded as feeding on corn (59). *Barathra configurata* Wlk., group V, an army worm that attacks almost any dicotyledonous plant. The injury to corn is similar to that of the corn ear worm, *Heliothis obsoleta* Fabr. (100). The species occurs in the western prairies from British Columbia to Mexico. *Porosagrotis orthogonia* Morr., the pale western cutworm, group VI, a grass insect that has done severe damage to corn in North Dakota (180). *P. vetusta* Walk., group VI, a general feeding cutworm that was destructive to corn in North Carolina (26). *Ceramica (Mamestra) picta* Har., group III (c), a truck crop species that is taken quite commonly feeding on silk of corn in the fall. Distribution—Atlantic states west to Kansas and Nebraska. *Polia (Mamestra) renigera* Stephens, group VI, a grass-root-feeding cutworm that has been found at the bases of corn plants in Illinois (59). *P. subjuncta* G. & R., group VI, a general feeder on grasses and weeds that has been recorded as attacking corn in Con-

necticut (16). *Nephelodes emmedonia* Cram. (*N. minians* Guen.), group VI, is occasionally very destructive to grasslands in Ohio and sometimes attacks corn when following grass.

Neleucania (Heliophila) albilinea Hubn., group VI, the wheat head army worm, prefers timothy to other plants but when extremely abundant will attack corn (178). Larvae of this species were collected several times on corn in July 1923, in north-eastern Ohio. *Cirphis (Heliophila) unipuncta* Haw., the army worm, group VII, feeds by preference on wild and cultivated grasses but, when abundant, is severely injurious to corn. Destructive in the United States east of the Rocky Mountains. *Cirphis pseudargyria* Guen., group VI, recorded as feeding on corn and other cereals and grasses in New York. Distribution—northern United States east of Rocky Mountains (59). *C. latiuscula* H. Schf., group VII, a tropical species that normally feeds on the larger grasses, including sugar cane, has been recorded as feeding on corn in Texas. The larvae occur in cultivated crops by migration from grasses (159). *Gortyna micacea* Esp., group III (c), the potato stem borer, is said to have attacked young corn plants in Nova Scotia in 1917 (67). *Achatodes zaeae* Har., group III (d), originally recorded as being injurious to corn, by Harris (77). This record has not been verified by later investigators. The species feeds normally within the stems of elder, *Sambucus canadensis*. *Papaipema cataphracta* Grt., group VII, taken in corn in Canada and mistaken for the European corn borer (67). Probably breeds in grasslands around the margins of fields and migrates to corn. *P. nitela* Guen., group VII, commonly known as the stalk borer, occurs frequently in corn around margins of fields where it has migrated from the grass border. *Mocis repanda* Fabr., the striped grass looper, group VII, occurs on wild and cultivated grasses and is recorded as feeding on corn in the Gulf Coast States after migration from its breeding ground (158). *Heliothis obsoleta* Fabr., the corn ear worm, group VIII, is commonly destructive to corn but also feeds on many other plant species. It is cosmopolitan in distribution but is most injurious in the South. *Epizeuxis aemula* Hubn., group O, feeds on dried leaves of various plants and is recorded as injurious to corn fodder in the shock in Mississippi (132). *Apamea nictitans americana* Speyer, group VI, taken as larvae boring in corn in Nova Scotia. Original habits in America not known but *A. nictitans* Borkh. is recorded as feeding on roots of grasses in England (67). *Mero-pleon cosmion* Dyar, group VI, a grass insect that attacks sugar cane and corn (20).

VI. *Lymantriidae*

Hemerocampa leucostigma S. & A., group III (d), feeds normally on foliage of shade and forest trees but also is recorded as feeding on foliage of corn (177). *Porthetria dispar* L., the gypsy moth, group III (d), is primarily a pest of forest trees but is included here because the larvae "occasionally feed on corn or other forage plants when tree foliage is not available". It occurs in the New England states.

VII. *Geometridae*

Pleuroprucha insularia Guen., group VIII, seems to prefer corn silk to any other food but also feeds on a number of weeds (5).

VIII. *Eucleidae*

Sibine stimulea Clem., group III (d), known as saddle-back caterpillar, feeds normally on foliage of various trees but is also taken quite commonly feeding on the leaves of corn in Ohio and other states.

IX. *Pyralidae*

Pyrausta ainsliei Heinr., group I, commonly known as smart-weed borer, feeds by preference on *Polygonum* but is thought to feed on corn in advanced larval stages. *P. futilalis* Led., group 1, normally feeds on the foliage of spreading dogbane, *Apocynum androsaemifolium*, but is occasionally found in a web back of the leaf sheath of corn to which it has migrated for shelter. *P. nubilalis* Hubn., European corn borer, groups VIII and IX, behaves like two species and for this reason is placed in two groups. In the New England area it is not limited to corn but feeds on a great variety of hosts. In the Lake Erie region it is definitely limited to corn except by migration. In the former case it is thus classed as an independent corn insect, group VII; while in the latter it is dependent, group VIII (21, 41, 91). *P. penitalis* Grote, the lotus borer, group I, is frequently found in corn stalks to which it has apparently come for shelter. *Pyralis farinalis* L., group SC-III, is a cosmopolitan species that infests all kinds of seeds, grains, and grain products (11). *Crambus calignosellus* Clem., *C. mutabilis* Clem., and *C. trisectus* Walk., group VI, are three species of sod webworms that were found quite commonly in corn fields of northwestern Ohio in 1925. Damage occurred only where the fields had previously been in grass or where weeds had formed a rather thick

growth. *C. leachellus* Zinck., group VI. A number of individuals doubtfully determined as this species by Mr. G. G. Ainslie were taken in a corn field near Oak Harbor, Ohio, in June, 1925. The field had previously been in alfalfa but had a thick growth of dandelion and other weeds. *C. praefectellus* Zinck., group VI, was seen to have injured severely a thirty-acre field of corn in Williams County, Ohio, in June, 1925. *C. luteolellus* Clem., group VI, is confused in the literature with *C. calignosellus* and *C. zeelus* but it is listed as a valid species in the *Lepidoptera of New York* by Dr. W. T. M. Forbes. *C. teterellus* Zinck., group VI. A specimen doubtfully determined as this species by G. G. Ainslie was taken in a corn field in Hancock County, Ohio, along with a great many *C. trisectus* Walk. The field had been in pasture for a great many years previously. *C. vulgivagellus* Clem., group VI, recorded as being associated with *C. trisectus* Walk. in injuring corn after sod in Illinois. *C. zeelus* Fernald, group VI, is said by W. T. M. Forbes in *Lepidoptera of New York* to be injurious to corn along with *C. calignosellus* Clem. (For literature on crambids see 3, 6, 7, 16, 59). *Diatraea saccharalis crambidoides* Grote, the sugar cane moth borer, group VI, is commonly taken in many of the larger stemmed grasses and is frequently very injurious to corn in the extreme southern states. *D. zeacolella* Dyar, the larger corn stalk borer, group IX, feeds primarily upon corn but also attacks other grasses. It occurs in the southeastern states. *D. grandiosella* Dyar, group VI, has been reported as destructive to corn in Arizona. It has habits similar to *D. zeacolella* but has only recently been reported as injurious (155, 161). *Ephestia keuhniella* Zell., group SC-III, has been imported from Europe where it has been a pest of small grains and grain products for many years. *Plodia interpunctella* Hubn., group SC-III, is a very general feeder on cereals, cereal products, fruits, nuts, and other foods. Distribution—world wide (11). *Elasmopalpus lignosellus* Zell., group VI, is injurious to corn in the southern states. The larvae tunnel the stems near the soil surface. They are almost omnivorous but show a decided fondness for grasses (9). *Nomophila noctuella* D. & S., group III (a), is primarily a pest of legumes but recorded as feeding on corn in Illinois (54). *Loxostege similalis* Guen., the garden webworm, group V, feeds by preference on a number of weeds, especially *Amaranthus* and *Chenopodium*, but is sometimes a severe pest of garden crops and occasionally attacks corn (99). *L. sticticalis* L., the sugar beet webworm, group V, shows a preference for several common weeds but, when these are consumed, attacks other vegetation, including corn (151).

X. *Lavernidae*

Pyroderces (Batrachedra) rileyi Wals., known as the pink corn worm, group II (a), is somewhat injurious to corn, both in the field and in storage, in the southern states. It is most commonly associated with injury by other insects and seems to have fed originally on insect remains and decaying vegetable matter (27).

XI. *Gelechiidae*

Sitotroga cerealella Oliv., group SC-III, known as the Angu-mois grain moth, is primarily a stored-grain pest that has been introduced from Europe. The moths fly to the field and infest the grain as it is approaching maturity, the damage being continued in storage (144, 145).

XII. *Tortricidae*

Epagoge sulfureana Clem., group III (f), a general feeder recorded as feeding on the foliage of corn in Illinois (59). Widely distributed east of the Rocky Mountains. *Cacoecia rosaceana* Har., group III (d), feeds usually on trees and shrubs but has been taken a number of times while feeding on corn in northwestern Ohio. *Eulia velutinana* Walk., group III (f), a very general feeder that includes corn in its list of food plants (28). Widely distributed east of the Rocky Mountains. *Sparganothis (Platynota) flavendana* Clem., group III (f), a general feeder that has been said to have attacked ears of green corn (59). *Tortrix clemensiana* Fernald, group O, has been taken a number of times in the act of feeding on the leaves and ear husk of corn in northern Ohio.

XIII. *Tineidae*

Tinea granella L., group SC-III, infests all kinds of cereals both in the field and in storage. Introduced from Europe and now generally distributed over eastern part of the country (11). *Acrolophus (Pseudanaphora) arcanella* Clem., A. (*Hypoclopus*) *mortipenellus* Grote, and A. (*Anaphora*) *popeanellus* Clem., group VI, are reported to have done noticeable injury to young corn in one or two instances in Illinois. Larvae feed mainly in grass land, injury to corn occurring only when planted on sod (59).

DIPTERA

The members of this order are of very slight importance as corn insects. While there are eight species that have been recorded

as injuring the corn plant, only two or three of them are known really to do damage to corn and in no case is the damage significant.

I. *Tipulidae*

Tipula costalis Say, group VI, feeds normally on the roots of plants in meadows, pastures, and grain fields. Reported by Webster to have been injurious to corn near Ashland, Ohio (168).

II. *Mycetophilidae*

Sciara sp., group VI. A species belonging to this genus, called by Forbes the black-headed grass maggot, is said to attack the seed of corn in the ground in cool wet seasons. It lives chiefly in old sod land and probably feeds normally on decaying vegetation in the soil (56).

III. *Syrphidae*

Toxomerus (Mesogramma) politus Say, the corn-feeding Syrphid, group II (b), is taken very commonly on corn in Ohio. It feeds mainly in the leaf axils and back of the leaf sheaths. It is said by Folsom (55) to be predaceous on the pea aphid, *Macrosiphum pisi* Kalt. This was likely its original habit. Distribution—eastern United States.

IV. *Ortalidae*

Chaetopsis aenea Wied., the corn stalk maggot, group II (a), is primarily a scavenger on decaying vegetable tissue but sometimes does slight injury to corn. It usually attacks the plant where other injury has preceded it. Distribution—east of the Rocky Mountains (56).

V. *Geomyzidae*

Diastata sp., group O. An undescribed species belonging to this genus was found by Comstock mining in leaves of corn at Washington, D. C., many years ago (37).

VI. *Agromyzidae*

Agromyza parvicornis Loew, the corn blotch leaf miner, group VIII, seems to show a preference for corn but also attacks other grasses which no doubt were original food plants. The species is common on corn in northern Ohio and is widely distributed throughout the United States (88, 126). *Cerodonta (Ceratomyza) dorsalis* Loew, the spiked horned leaf miner, group VIII, has been recorded frequently as occurring on corn throughout the United States. The species also feeds readily on a number of other grasses (106).

VII. *Anthomyidae*

Hylemyia cilicrura Rond. (*Phorbia fusiceps* Zett.), the seed corn maggot, group II (a), is commonly reported as being injurious to seed corn in the ground during cold wet seasons. It likely feeds normally on decaying vegetable and animal matter. Occurs throughout the United States.

HYMENOPTERA

While there are twelve members of the order Hymenoptera included here, their injury is more or less incidental and as corn insects they are of little importance.

Formicoidea

Monomorium minimum Buckley (*M. minutum* Mayr), group O, is recorded as occurring rather commonly at exposed tips of ears where they gnaw soft and imperfectly developed kernels (59). *M. pharaonis* L., group O, reported by Fitch as doing a great deal of damage to young corn in New York in 1850 when they gnawed the leaves to procure the sap exuding from the wounds (53). *Formica pallidefulva* subsp. *schaufussi* Emery, group O, observed by the writer and also recorded by Forbes as gnawing exposed kernels on ears of corn in the fall. It is commonly seen in attendance upon the corn leaf aphid and corn root aphid (59). *Myrmica scabrinoidis* subsp. *schencki* Emery, group O, is injurious to seed corn in the ground and also feeds on exposed kernels at tips of ears. Commonly seen attending corn leaf aphid (59). *Pogonomyrmex barbatus* F. Smith, group O, sometimes does incidental injury to corn by removing all vegetation near nest (113). *Solenopsis molesta* Say, group O, does a great deal of damage in Kansas by gnawing off the tender blades of young plants of sorghum, kafir, and corn. Commonly associated with corn root aphid but also occurs alone (83). *Prenolepis imparis* Say, group O, is recorded as attending the corn leaf aphid and also as feeding on injured kernels at tips of ears of corn (59). *Lasius niger* L. var. *americanus* Emery, group O, commonly called the corn field ant, is said to have done severe injury to seed corn in the ground. It is very commonly found attending the corn root aphid (60). *Atta mexicana* F. Smith (*A. fervens* Say), group O, recorded as injuring corn in Texas by cutting off fragments of fresh leaves and taking them to the nests (112).

OTHER HYMENOPTERA

Ametastegia glabrata (Fall.), dock false worm, group III (b), has been taken repeatedly as a green larva in the pith of corn stalks at Columbus and Oak Harbor, Ohio, in fall and spring. It occurs normally in dock and Polygonum. *Emphytina tener* (Fall.), group O. An individual of this species was seen hollowing out the pith in a broken stalk of old corn at Willoughby, Ohio, in June, 1924. *Halictus lerouzii* Lep., group III (e), was observed to gather pollen from corn and a great many other plants (59).

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