INSECTS ASSOCIATED WITH IRONWEED (*VERNONIA INTERIOR* SMALL), AN IMPORTANT PASTURE WEED IN EASTERN KANSAS

by

RICHARD BLAINE SCHWITZGEBEL

B. S., Kansas State College of Agriculture
and Applied Science, 1939

A THESIS

submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE

Department of Entomology

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1941

TABLE OF CONTENTS

INTRODUCTION

In a study of insect populations of pasture grasses and pasture weeds an opportunity was afforded to observe and study the biology of the insects associated with ironweed, (Vernonia interior Small), one of the major pasture weeds of Kansas.[1] Other species of Vernonia (ironweed) occur in Kansas but since V. interior was more abundant than the other species it was selected for this investigation.

Since ironweed is locally abundant and of widespread distribution, those insects associated with it are of importance in at least the following three ways:

1. They hinder its growth and prevent to some extent its spread and propagation as a result of their feeding activities.
2. Some of these insects are associated with other pasture flora and even cultivated crops.
3. Ironweed insects provide a reservoir for parasites which may ultimately attack injurious insects.

This study was started in June 1939 and continued until May 1941. Field observations, collections, population studies, and rearing immature insects were conducted throughout the two year period. The major part of the research was

---

[1] This study was made in part while employed on Bankhead-Jones project 211 of the Kansas Agricultural Experiment Station.

carried on in the vicinity of Manhattan, but some data secured by Mr. S. C. Schell, who reared several species of ironweed insects in Doniphan County, Kansas, has been incorporated in the thesis. Mr. G. P. Engelhardt sent information concerning some lepidopterous larvae associated with ironweed in eastern United States.

All the data secured during this investigation regarding the description, life history, habits, abundance, and relationship to the plant of about 50 species of insects which are associated with ironweed are presented in this paper. Discussions of insect injury to the plant and interrelationships of ironweed insects, such as parasitism, predatism, and commensalism, are also included.

REVIEW OF LITERATURE

At present there appears to be but little published information upon insects associated with ironweed. About the only available data are host plant records which are scattered and meager. These data were located by rearing or collecting insects from ironweed, having them determined, and then searching the literature for host plant records. There is still less information upon the relationship of the insects to the plant. However, eight references were found which referred to insects which had been reared or collected from the plant. All except two of these were host plant records and did not discuss the biology of the insects or their relationship to the plant.

Twenty-two species have been reported in the literature as having been collected or reared from the various species of Vernonia. Loew (1862) described four Trypetidae which had been reared from ironweed in Pennsylvania. Fernald (1898) reported a Pterophoridae which fed on V. noveboracensis in Ohio, Illinois, Missouri, Texas, California, and Oregon. Beutenmuller (1907) described a gall midge which was taken from V. noveboracensis. Felt (1911, 1916) described two other ironweed gall midges. Blatchley and Leng (1916) reported that four Curculionidae were swept from Vernonia in Indiana. Painter (1935) reared a trypetid gall-maker from ironweed in Texas and also a gall midge which had previously been reported. Patch (1938) listed nine species of Aphididae which fed on Vernonia.

MATERIALS AND METHODS

Ironweed

Description. Ironweed, Vernonia interior Small, is a member of the composite family. Some of its relatives are the sunflowers, goldenrod, marigold, asters, and thistles. When the term ironweed is used while discussing plants growing in Kansas, reference is made to V. interior; otherwise, when the term ironweed is used it denotes Vernonia spp.

Rydberg (1932) gave the following description of the plant:

> Coarse erect perennials with alternate leaves. Inflorescence corybos-paniculate. Receptable

> flat; corollas mostly purple or rose; 5 cleft with narrow lobes; achenes 8-10 ribbed, truncate at apex; callous at base. Leaves wide, elliptic or elliptic-lanceolate, 6-20 cm. long accuminate, sharply serrate, glabrous or scabrellous above, thinly tomentose and resinous, not pitted beneath. Involucre capanulate, 6-7 mm. high; bracts purple or green with purple margins, accuminate, resinous on back, erect or slightly spreading.

Aldous (1935) stated:

> Ironweed is first established by seed and then spreads rapidly by thrifty root stalks to form a large clump frequently containing one hundred stems. The roots of ironweed do not penetrate the soil more than three or four feet, even in fertile soil most of the roots are concentrated in the surface foot. This weed is able to grow under extremely dry conditions. It starts growth early in the spring ahead of most of the native forage plants.

Ironweed blooms in eastern Kansas from July to September. The height of the plant is quite variable depending on its environment. In upland pastures it varies from two to three feet but in ravines or fertile soil it may grow more than six feet tall.

Distribution. According to Gates (1940) ironweed grows on the prairies, dry prairies, pastures, and waste lands. It has been reported from all counties in Kansas except 24 in the western and southwestern part of the state as indicated in Fig. 1.

Economic Importance. *Vernonia interior* has been considered for several decades to be one of the most important pasture weeds in eastern Kansas, ranking along with sumac, vervain, buckbrush, and ragweed.

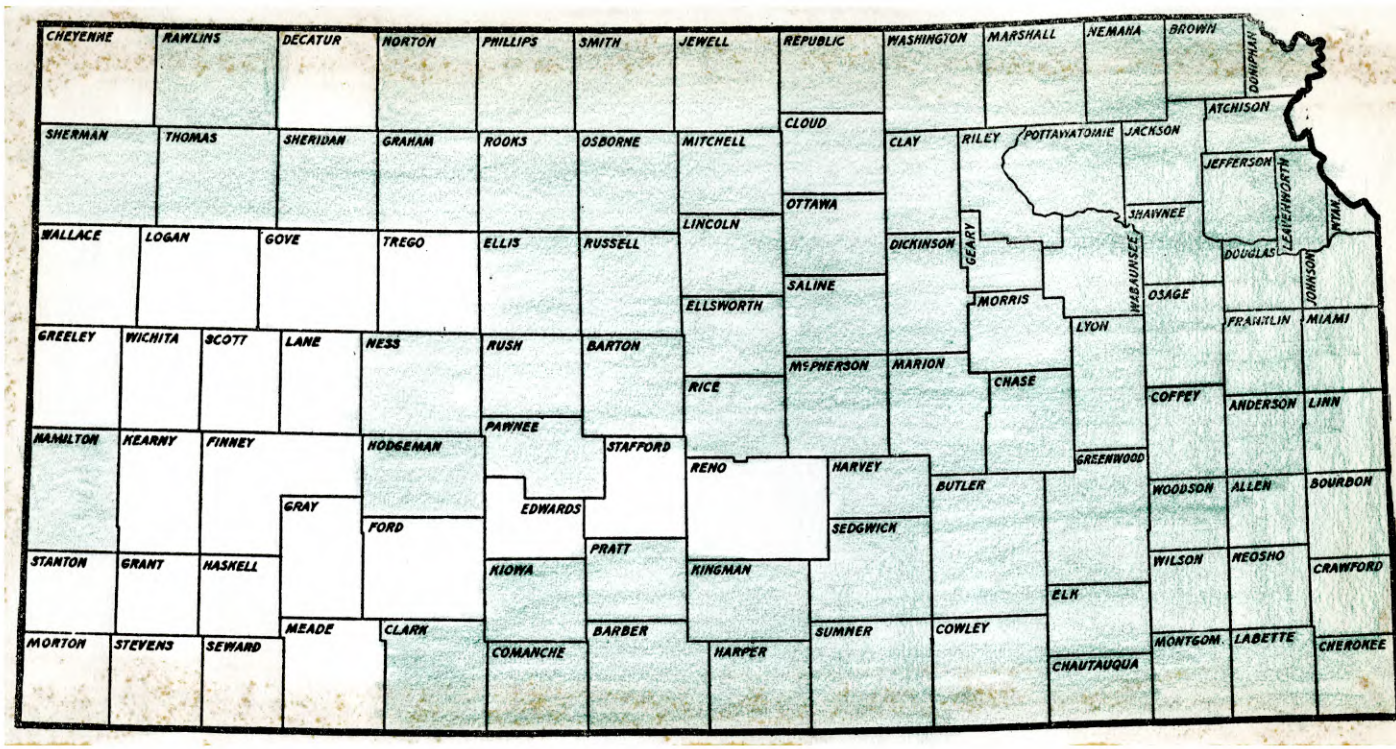


Fig. 1. Distribution of ironweed in Kansas.

It is a native of the prairies and before the prairies were used for cattle grazing the grasses gave it no chance to build up to an obnoxious abundance. During the past fifty years poor pasture management has been largely responsible for ironweed and other weeds getting started in the pastures and now their removal is a problem.

According to Aldous (1935) "it is necessary to eradicate ironweed from the pasture as it can compete successfully with grasses under all stages of grazing." Professor K. L. Anderson of the Kansas Agricultural Experiment Station recommends that ironweed be mowed each year about the middle of June depending on the season.

Methods of Studying Insects

This study was started in June 1939 and rearing of insects and field observations were carried on continuously until May 1941, except during the month of June 1940. During the growing seasons of this period an attempt was made to make collections and field observations about twice each week. No field work was carried on during December, January or February.

Sources of ironweed included several pastures west and north of the city of Manhattan, a sandy upland pasture in western Pottowatomie county known as the Little Gobi Desert, and one pasture in eastern Doniphan County.

All available stages of insect life were brought to the laboratory and an effort was made to rear the immature forms. Several different methods of rearing these insects were employed.

Some of the insects associated with the stems of ironweed were reared successfully in cardboard cyclinders (empty adhesive tape containers) fitted with a glass vial on one side near the middle. Upon emerging the insects moved to the vial, the source of light, where they were and could be easily collected. Stems of the plant were placed in one series of these containers and the flowers in another group. Those insects which were reared in this manner included Trypetidae, Membracidae, and parasites of the Cecidomyiidae and Trypetidae.

Such an arrangement was simple to employ and provided many specimens. It also permitted the collection of specimens on the day they emerged without disturbing other insects

which had not yet become adults.

Since the stems of ironweed were hard and woody, it was difficult for the gall midges to emerge in the spring until after sufficient moisture had been supplied to soften the stems. This was accomplished by sticking the stems with galls in a flower pot of wet sand. A net-covered glass lamp chimney was placed over the stems to prevent the escape of the midges. A few adults were reared but this arrangement was not very successful because the stems rotted quickly. To prevent this, stems were placed in a lamp chimney, which was covered with netting at both ends, and then set in wet sand. This plan also prevented insects, which may have been in the sand, from emerging within the rearing cage and being confused with those emerging from the stems.

This rearing procedure was quite successful; a large series of adults were collected about one month before they started emerging in the field. Parasites also emerged in large numbers in these rearing cages.

A third method of rearing the midges was tried but with less success. Galls were collected from the field in April and soaked in a tub of water for 24 hours in an effort to soften the epidermis. The wet stems were placed in empty shoe boxes and a glass vial was inserted at one end of each box of galls to allow for the removal of emerged adults. The shoe box method of rearing was adapted from Wilbur and Fritz (1939). A few midges emerged but other insects such as mordellid adults, their parasites, and parasites of the midges, were

reared in greater abundance.

Those insects reared from galls under moist greenhouse conditions emerged much earlier than did those which were reared in the shoe boxes. In the latter case the life cycle of the insects was retarded by a lack of moisture. In the greenhouse favorable conditions produced adults earlier than in the field. Emergence dates of insects reared in shoe boxes probably corresponded more nearly to actual emergence dates in the field than did those reared in the greenhouse.

The stem borers provided the most difficulty in rearing. Stems were brought into the laboratory, split open and examined throughout the growing season to determine the insects present, stage of growth, and abundance. In April and May larvae and pupae were collected from the previous year's stems, placed in glass vials, and kept in a dark place until emergence took place. The adults and parasites of the coleopterous stem borers were secured in this way.

In the spring young ironweed plants were brought into the greenhouse and transplanted into flower pots. Gall midges and adults of the stem borers were caged with these young plants in an effort to secure eggs, but this procedure was unsuccessful.

For the purpose of rearing lepidopterous larvae such as the Arctiidae and Pterophoridae, which fed on the leaves of ironweed, a dozen young ironweed plants were transplanted from a pasture just wast of Manhattan to an insectary plot which is about one-half mile east of the pasture. Some plants were caged with insects, some were used as a source of food for

those insects caged in the laboratory, and other plants were allowed to grow unmolested in order to attract the lepidopterous leaf feeders mentioned above.

Lepidopterous larvae were brought into the laboratory from the field and placed in rearing cages. At first, glass tumblers with a supply of soil in the bottom were used. Cloth netting was fastened over the top of the tumbler to prevent the escape of the specimens. Sufficient ironweed leaves were supplied for food and moisture was added to the soil at irregular intervals, depending upon the condition within the cage. Some insects pupated and emerged in this type of cage but many more died as a result of fungous growth.

In efforts to prevent the development of fungus, cellucotton was substituted for the layer of soil in the bottom of the cage. Cellucotton seemed to be as suitable for pupation as the soil. Since cellucotton absorbed water readily and did not form a hard crust on top when it became dry, it was much easier to handle than soil. The larvae utilized cellucotton particles in making their cocoons and because of the translucent nature of this material the pupae were easily located.

EXPERIMENTAL DATA

Insect-plant Relationships

The structure and growing habits of ironweed, Vernonia interior, influenced the abundance of insects which fed on the plant as well as the large number of species which were collected from it. Ironweed may be attractive to insects in at least the following three ways:

1. Its large leaves usually grow one or two feet above the surface of the soil and provide good shelter.
2. It remains green and succulent throughout the growing season even though drought may cause the rest of the pasture to turn brown.
3. Its large pithy stems provide much food and shelter for burrowing insects.

At least 50 species of insects, comprising 25 families and seven orders, fed on ironweed. Approximately 1700 specimens of 34 these species were taken from V. interior in eastern Kansas. Several of the other 16 species not observed to be associated with the plant during this study probably occur in Kansas.

More than 800 individuals were swept from ironweed plants but their relation to it was not determined. This group included over 130 species representing more than 50 families and nine orders. Parasitic and predatious insects are not included in this group since they are discussed in another part of this paper.

It was observed that grasshoppers resorted to ironweed leaves for food during the summer of 1940 in several pastures because of the dry conditions of the pasture. No doubt other insects such as leafhoppers, leaf beetles, and various hemipterons were attracted to V. interior for both food and shelter during unfavorable growing conditions.

Table 1 shows the taxonomic distribution of insects associated with ironweed. Table 2 shows the seasonal cycle of ironweed and of eight insects which fed on the plant.

Injury to the Plant

The roots, stems, leaves, and the flower parts of ironweed were all subject to insect attack as indicated by Fig. 2. Eight species attacked the flowers and seeds; 15 occurred on the stems; 10 fed on the leaves; four formed galls; eight burrowed inside the stems; two burrowed inside the roots and crowns; three fed on the roots. Although ironweed was liable to infestation by such a host of insects, no plants were killed by insects.

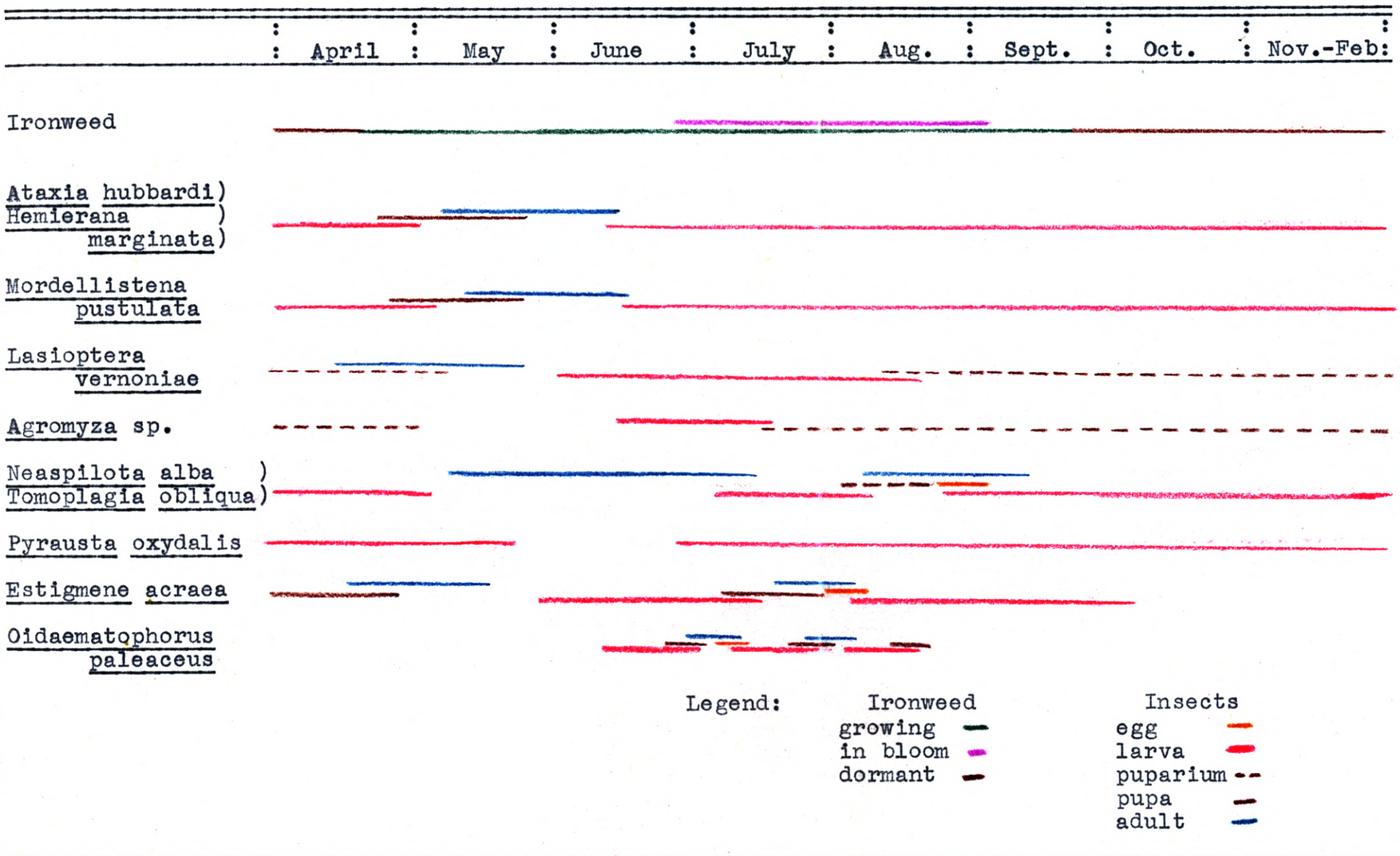
Those insects, which fed on the seeds and roots, and those which hindered the development of the flowers did more than any other group of insects to limit the propagation of the plant. The stem borers, root borers, gall midges, flower and seed feeders were most important in this respect.

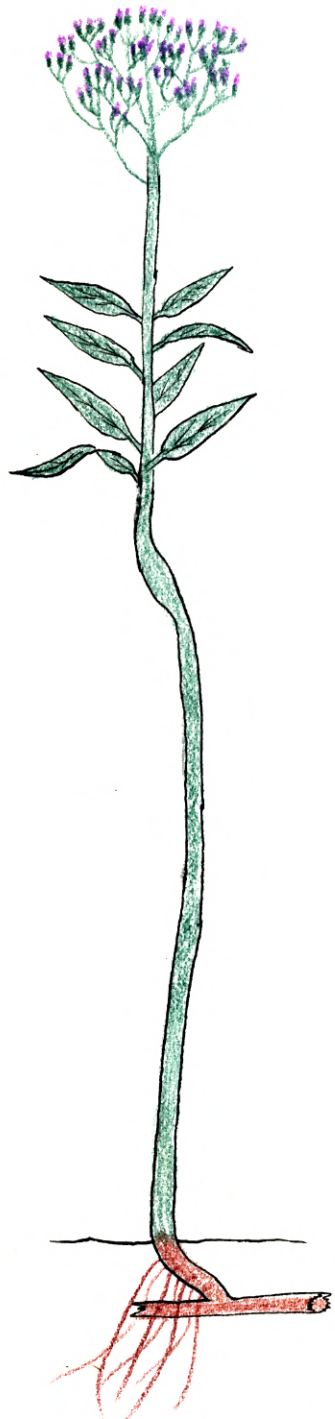
The stem borers actually consumed more of the ironweed plant than any other group of insects. By the end of the growing season most of the stems were hollowed out to various

Table 1. Taxonomic distribution of ironweed insects, not including parasites, predators, and commensals.

Order Family	Number of species		
	Observed feeding	Collected but relationship to plant unknown	
		immature	adult
Orthoptera			
Acrididae	2	2	2
Tettigoniidae	1	2	2
Gryllidae	1		
Isoptera			
Termitidae	1		
Coleoptera			
Histeridae			1
Cantharidae			1
Melyridae		1	
Cleridae			1
Mordellidae	1		3
Meloidae	2		1
Elateridae	1		1
Buprestidae			1
Dermestidae			1
Coccinellidae			1
Scarabaeidae	1		1
Cerambycidae	3		2
Chrysomelidae			9
Anthribidae			1
Curculionidae	4		7
Hemiptera			
Cydnidae			1
Pentatomidae	1	1	4
Coreidae			3
Lygaeidae			4
Reduviidae		1	1
Nabidae			1
Anthocoridae			1
Miridae			7
Neididae			1
Piesmidae			1
Homoptera			
Cercopidae	1		
Membracidae	1		
Cicadellidae			22
Aphididae	10		
Trichoptera			1
Lepidoptera			
Pterophoridae	1		
Phaloniidae	2		
Aegeriidae	1		
Pyralididae	1		
Noctuidae	2		
Arctiidae	1		
Unknown	2		
Diptera			
Chironomidae			1
Cecidomyiidae	3		
Bombyliidae			1
Therevidae			1
Asilidae			1
Dolichopodidae			2
Empididae			1
Helomyzidae			1
Borboridae			1
Sapromyzidae			2
Trypetidae	6		2
Sepsidae			1
Ephydridae			1
Chloropidae			8
Agromyzidae	1		3
Anthomyiidae			1
Muscidae			2
Sarcophagidae			1
Tachinidae			4
Hymenoptera			
Argidae			1
Cynipidae			1
Eurytomidae			1
Mutillidae			1
Tiphiidae			1
Formicidae			1
Vespidae			1
Sphecidae			2
Halictidae			1
Anthophoridae			2
Totals	50	8	126

Table 2. Seasonal cycle of ironweed and eight insects which feed upon it.





Flowers and Seeds
- Trypetidae (5)
- Cecidomyiidae (2)
- Phaloniidae (2)
- Aphididae

Leaves
- Pterophoridae
- Arctiidae
- Unknown Lepidoptera (2)
- Meloidae (2)
- Acrididae (2)
- Gryllidae
- Tettigoniidae

Stems (galls)
- Cecidomyiidae
- Trypetidae

Stems (outside)
- Curculionidae (4)
- Pentatomidae
- Cercopidae
- Membracidae
- Aphididae (8)

Stems (inside)
- Aegeriidae
- Noctuidae (2)
- Cerambycidae (3)
- Mordellidae
- Agromyzidae

Crown and Roots (inside)
- Pyralididae
- Termitidae

Roots (outside)
- Aphididae
- Scarabaeidae
- Elateridae

Fig. 2. Ironweed insects and the parts of the plant they attack.

degrees by one or more of the six species of borers. These stems were weakened and fell to the ground when dry with nothing left of the stem above the ground except a hollow cylinder. The effectiveness of these borers in hindering the development of the flowers depended on how much of the conductive tissues of the stem was destroyed.

The cecidomyiid galls caused the stems to bend, split, and become so brittle that they were easily broken off. A few stems, which were bent and split by galls, produced only a few flowers. A large number of closely compacted galls on the stem was necessary to bring about this condition. (Figs. 3, 4, 5). Those stems with only a few galls scattered along the stem exhibited no harmful effects.

Those insects which fed on the flower parts and seeds were directly responsible for a 25 percent reduction in the seed production of the plant. Some of the species fed on the seeds and others consumed all of the flower parts. The feeding of the trypetids on the seeds prevented the involucres from opening, thus providing the larvae with winter protection.

The lepidopterous root borers fed in the crown, underground stems, and roots leaving them quite hollow after five months of burrowing. No data were secured to indicate how this feeding effected the plant but it was noticed that plants were able to produce a few new shoots in the spring even though parts of the crown and roots had been eaten away by the borers.

Fig. 3. Cecidomyiid galls in ironweed stems. Stem at extreme right was not infested.

Fig. 4. Cecidomyiid galls in ironweed stems.

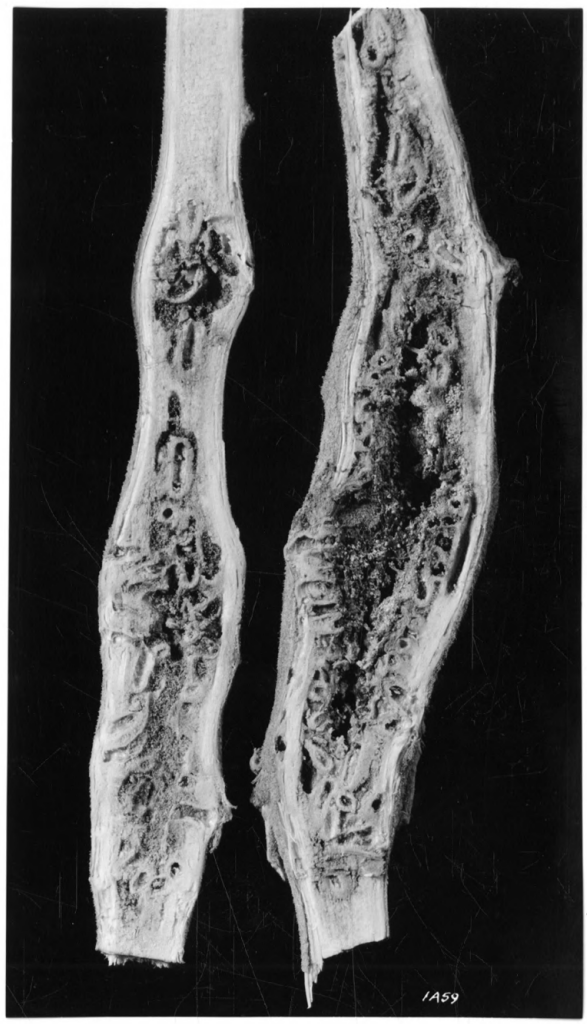


Fig. 5. Longitudinal section of ironweed stems showing closely compacted cecidomyiid galls.

Very little damage was done to the plant by those insects which fed on the leaves. A large percentage of the plants had a few ragged and skeletonized leaves but the proportion of the leaves attacked to those which were not harmed was small. Blister beetles were observed in the act of completely defoliating one ironweed plant.

To determine the abundance of some of the major ironweed insects a population study was conducted during August and September of 1940. One hundred twenty-eight stems were selected at random from several of the pastures near Manhattan and the insects that fed on the plant were counted.

Table 3 indicates the relative abundance of several of the species which fed inside the stems.

Table 3. Relative abundance of six ironweed stem borers.

Species	Number of stems examined	Number of stems infested	Percentage infestation
Agromyza sp.	128	16	12.5
Ataxia hubbardi) *Hemierana marginata*)	128	51	40
Lasioptera vernoniae	128	73	57
Mordellistena pustulata	103	99	96
Pyrausta oxydalis	128	54	19

In the case of the gall midges (*L. vernoniae*) there was an average of 11 galls per stem. The number of the mordellid larvae in each stem varied from one to seven with two being the average.

Flowers of three-fourths of the stems examined were hosts to the trypetids. About one-third of the flowers on these stems were infested which indicated that 25 percent of the total number of flowers in the field were attacked. All the seeds of each infested involucre were consumed and there was but one maggot per involucre.

No data concerning the abundance of other insects that fed on the plant were collected.

Interrelationships of Insects

Parasitism. More than 1500 hymenopterous parasites were taken from six species of insects associated with ironweed. This group comprised 12 families and 37 species, nine of which have not been described. Some of the parasites may have been hyperparasites but only one species was reared from a primary parasite. Another ironweed insect was parasitized by a dipterous species but the parasite was not reared or determined.

Table 4 lists the parasites of ironweed insects and their hosts. Since it was supposed that the parasites of the trypetid seed maggots attacked all five species, the family name Trypetidae was used in Table 4 to include this group.

The percentage of parasitism varied with the species concerned, as indicated in Table 5, which lists the species attacked, the number of species of parasites for each host, and an estimation of the relative abundance of the parasites. The method by which percentage of parasitism was derived is explained in this paper in the discussion of the host concerned.

Table 4. Known parasites of ironweed insects and their hosts.

Species	Number specimens reared and collected	Host
Braconidae		
Apanteles lunatus (Pack.)	4	Trypetidae
Apanteles epinotiae Viek.	3	Trypetidae
Heterospilus languriae (Ashm.)	2	Trypetidae
Iphiaulax sp.	2	*Lasioptera vernoniae*
Iphiaulax sp.	1	(*Ataxia hubbardi* (*Hemierana marginata*
Microbracon nuperus (Cress.)	190	Trypetidae
Monogonogastra agrili (Ashm.)	2	(*A. hubbardi* (*H. marginata*
Rhaconotus n. sp.	1	Trypetidae
Schizoprymnus n. sp.	40	*Mordellistena pustulata*
Trichacis rubicola Ashm.	1	*L. vernoniae*
Trichacis rubicola var.	19	*L. vernoniae*
New genus, new species	3	*L. vernoniae*
Platygasteridae		
Platygaster sp.	2	*L. vernoniae*
Cynipidae		
Melanips iowensis Ashm.	1	Trypetidae
Callimomidae		
Callimome n. sp.	90	*L. vernoniae*
Callimome n. sp.	12	*L. vernoniae*
Chalcididae		
Brachymeria fonsocolombei (Dufour)	1	Trypetidae
Ceratosmicra paya Burks	2	*Oidaematophorus paleaceus*
Elasmidae		
Elasmus setosiscutellatus Cfwd.	3	Trypetidae
Eulophidae		
Elachertus sp.	1	*O. paleaceus*
Elachertus sp.	2	Trypetidae
Tetrastichus sp.	(10	Trypetidae
	(43	*L. vernoniae*
Eupelmidae		
Eupelmus allynii (French)	(3	*L. vernoniae*
	(30	Trypetidae
Eupelmus sp. (near *cyaniceps* var. *amicus* Gir.)	47	Trypetidae
Eurytomidae		
Eurytoma n. sp.	(1	*L. vernoniae*
	(312	Trypetidae
Eurytoma n. sp.	76	*L. vernoniae*
Eurytoma n. sp.	139	Trypetidae
Eurytoma sp.	1	Trypetidae
Mymaridae		
Gonatocerus sp.	1	Trypetidae
Polynema caesariatipenne Gir.	1	Trypetidae
Polynema bifasciatipenne varium Gir.	4	Trypetidae
Pteromalidae		
Catolaccus aeneoviridis (Gir.)	4	*O. paleaceus*
Catolaccus kansensis Gir.	1	Trypetidae
Habrocytus purpureiventris (Ashm.)	274	Trypetidae
Merisus n. sp.	6	*Iphiaulax* sp.
Other Chalchidoidea		
Amblymerus sp.	1	Trypetidae
Zaglyptonotus schwarzi Cfwd.	204	Trypetidae
Total	1540	

Table 5. Number of parasites and percentage parasitism of seven ironweed insects.

Host	Number of species	Estimated percentage parasitism
N. alba)		
T. obliqua)	22	90
L. vernoniae	11	over 50
O. paleaceus	3	low
A. hubbardi)		
H. marginata)	2	low
M. pustulata	1	80

Besides the known parasites of ironweed insects 41 hymenopterous parasites were swept from the plant and some of them probably were associated with other ironweed insects. Seven families and 25 species, three of which were undescribed were represented in this group. Table 6 lists the species, specimens collected and the month of collection. Table 7 is a summary of parasitic insects reared and collected from ironweed.

Predatism. All the life stages of two species of Chrysopidae, Chrysopa plorabunda Fitch and Chrysopa oculata albicornis Fitch were found on ironweed from May until October. There were at least two generations each year.

On several occasions unidentified ground beetle larvae (Carabidae) were found feeding on stem and root borers. A few Hippodamia convergens Guer, adults and one pupa were found on ironweed.

Commensalism. The following six species of ants (Formicidae) were associated with the two species of aphids which fed on ironweed: Cremastogaster opaca puctulata Em.,

Table 6. Parasitic insects collected from ironweed. (Relationship to ironweed insects not established.)

Species	Number specimens collected	Month of Collection
Braconidae		
Apanteles n. sp.	1	Sept.
Apanteles femur nigrum (Prov.)	1	May
Apanteles sp.	1	May
Blacus sp.	1	June
Chelonus sp.	1	Aug.
Dacnus sp.	3	May
Microctonus eleodis Vier.	1	June
Microbracon sp.	2	July, Aug.
Microbracon mellitor (Say)	1	May
Opius n. sp.	2	May
Orgilus n. sp.	2	June
Urosigalphus femoratus Cfwd.	6	Aug.
Cynipidae		
Eucoila sp.	2	May, July
Eucoilidea sp.	1	May
Neralsia hyalinipennis (Ashm.)	1	July
Ichneumonidae		
Cremastus orbitalis (Cress.)	1	May
Cryptus persimilis Cress.	2	June
Paniscus spinipes Cush.	1	June
Callimomidae	1	Aug.
Eurytomidae	1	Aug.
Eurytoma phoebus Gir.	1	Aug.
Harmolita sp.	1	May
Pteromalidae		
Merisus sp.	3	May
Other Chalcidoidea		
Dirhinus texanus (Ashm.)	3	Sept.
Haltichella sp.	1	Aug.
Total	41	

Table 7. Summary of parasitic insects reared and collected from ironweed.

Families	Number of species Table 4	Table 6
Braconidae	12	12
Ichneumonidae		3
Platygasteridae	1	
Cynipidae	1	3
Callimomidae	2	1
Chalcididae	2	
Elasmidae	1	
Eulopidae	3	
Eurytomidae	4	3
Eupelmidae	2	
Mymaridae	3	
Pteromalidae	4	1
Other Chalcidoidea	2	2
Totals	37	25
Total species		62

Cremastogaster lineolata subopaca Em., Cremastogaster sp., Dorymyex sp., Prenolepis imparis (Say), Leptothorax pergandei Em.

Leaf-consuming Insects

The ten species of insects which fed on the leaves represented families Pterophoridae, Arctiidae, Meloidae, Tettigoniidae, Gryllidae, and Acrididae. Two lepidopterous larvae, which were observed eating V. interior leaves, were not reared, consequently, their identification was not learned. None of these insects were particularly injurious to ironweed.

Oidaematophorus paleaceus Zell. (Pterophoridae; Lepidoptera). This species of plume moth was reared from V. interior during this study. Fernald (1898) reported that this same species, formerly placed in the genus Pterophorus, fed on Vernonia noveboracensis in Ohio, Illinois, Missouri, Texas, California, and Oregon.

Description. The egg was discoid, light green, 0.31 mm. wide, 0.47 mm. long, 0.17 mm. thick. The white to light green larva was subcylindrical, 9-12 mm. long, 1.5-2 mm. in diameter when mature, and covered dorsally with tufts of long hairs. The pupa was about same size as mature larva and became dull yellowish-brown just before emergence. It suspended itself from leaf with the anal hooks attached to a mat of silk on the leaf. Fernald (1898) gave the following description of the adult: "Expanse of wings, 21-25 mm. Head yellowish-brown,--thorax dull yellowish white. Abdomen dull yellowish, with fine longitudinal brownish lines...wings very pale brownish gray..." The specimens reared and collected in the vicinity of Manhattan had a wingspread of about 20mm. The body was about 10 mm. long.

Injury to Plant. The larvae fed on the young tender leaves of the plant from June until September. The extent of injury varied from complete skeletonization to partial consumption of the leaf though in general the amount of the injury was slight. The larvae were small and completed their life cycle quickly requiring only a small amount of food. However, if the insect becomes abundant in the field as it did in an experimental plot, serious injury to the plant can result. Young plants were brought from the field and transplanted in early June. By August the plants were only about half grown but the O. paleaceus larvae were so abundant that almost every leaf of each plant had been completely skeletonized.

Abundance. Adults were seldom seen in the field since they were nocturnal. The larvae were collected from June to September. There were fewer larvae during August than in June and July. Seldom was more than one individual found on a single leaf but 10-15 larvae were collected from one plant on one occasion.

Life History. The generations of O. paleaceus overlapped to such a degree that it was difficult to determine the actual number. Rearing data and field observations indicated at least four generations and possibly one or two more.

No overwintering form was found. In the spring eggs were laid on the underside of the young leaves adjacent to one of the larger veins. The newly hatched larvae fed in the vicinity of the veins for several days before venturing out onto the more unprotected portions of the leaf.

Fernald (1898) described the pupating activities as follows:

> When mature, it (larva) weaves a dense mat of silk, upon which it extends itself remaining quiescent for two or three days...the pupa's ventral surface is closely appressed to the mat of silk, to which the anal hooks are firmly attached. An upright or inverted horizontal position seems to be preferred although there is no thoracic band or other support for the anterior part of the body. Pupa is active and irritable.

As indicated in Table 8 the newly hatched larvae collected in the second week in July fed from 8 to 11 days before pupating. In the laboratory the average duration of pupation was 6.5 days with a range of 4-9 days. From two to three weeks were required

Table 8. Time required for the development of O. paleaceus larvae and pupae.

Date of collection	Growth stage	Date of pupation	Date of emergence	Generation
July 12	just hatched	July 20		II
July 12	just hatched	July 22	July 29	
July 12	just hatched	July 23	July 29	
July 18	larva	July 20	July 29	
July 18	larva	July 22	July 29	
August 1	larva	August 2	August 9	III
August 2	larva	August 3	August 7	
August 1	larva	August 3	August 9	
August 5	larva	August 5	August 9	
August 5	larva	August 12	August 19	
August 5	larva	August 10	August 16	
August 5	larva	August 12	August 20	

for the completion of the life cycle in the laboratory. If this was approximately the same length of time as was required in the field, this species could have had five generations each season, since young leaves were available to the larvae from the middle of May until September.

Rearing data gave evidence of at least four generations. The earliest collection date of larvae was the second week in July. At this time eggs were also found along with evidences of newly emerged adults. Two additional generations were reared in the laboratory.

Habits. The adults usually fly on warm, calm evenings, according to Fernald (1898), and are occasionally attracted to lights but rarely to sugar. In the daytime they may be flushed from the plants but they fly only a short distance and alight. When at rest they hold their wings nearly horizontal and at right angles with the body, but the plumes of the hind wings are folded over each other and drawn under the forewings.

Predatism and Parasitism. Fernald (1898) stated the probability that the plume moths are preyed upon by birds. Bird feces were observed frequently on leaves of V. interior in the vicinity where paleaceus larvae were feeding.

Seven hymenopterous parasites of the following three species were reared from the larvae: Catolaccus aeneoviridis (Gir) (Pteromalidae), Elachertus sp. (Eulopidae), and Ceratosmicra paya Burks (Chalcididae).

Estigmene acraea Drury. (Arctiidae; Lepidoptera).

Description. The eggs of this moth are yellow, spheroid, and about 0.8 mm. in diameter. The larva was variously colored depending on its stage of growth. The first instar individual was light gray covered with long black hairs and had a black head capsule. After it molted the black tubercles from which

the hairs protruded became more prominent as did a white dorsal stripe. Older larvae were dark dorsally with a series of light colored tubercles on each side. These larvae molted to become yellowish and these in turn transformed to dark colored larvae with gray to black hairs. The full grown larva was about two inches long. The cocoon was gray and appeared to be constructed from hairs shed by the pupating larva. The pupa was dark reddish brown. The female had white wings with black markings. The abdomen was orange with several series of black dots or bars. The male had orange back wings and sometimes parts or all of the front wings were dull orange. Otherwise the two sexes were marked about the same.

Injury to Plant. These salt-marsh caterpillars fed on the leaves of the plant. They were found in the field as early as May and as late as the first week in October. In the laboratory they consumed all of the leaf except the midrib or a few large veins. However, in the field, where food was abundant, they seldom fed on more than the apical half of any one leaf usually devouring parts of it, then going to another leaf or often to another plant for additional food.

During its life cycle each individual required a large amount of food but because of the hardiness of the plant and the relatively low abundance this species was probably responsible for little harm to the plant. This insect is not specific on ironweed but is known to feed on many other plants both wild and cultivated (Metcalf and Flint, 1939).

Abundance. No actual study was made to determine the abundance of this insect. Larvae were collected several times from the field for rearing purposed and about thirty minutes was usually required for the gathering of 15-20 specimens. Only one adult moth was collected from ironweed during the two seasons of investigation.

Life History. There were two generations in the Manhattan area. The pupae overwintered in the ground. The time and place of oviposition of the first generation was not ascertained but it is supposed that it took place during the first part of May on the foliage since partly grown larvae were found on the plant in May. Larvae became full grown by July and pupated in the soil.

Fourteen larvae pupated in the laboratory. The time of pupation ranged from July 1 to July 23, the average date being July 16. The mean emergence date was July 30, the first record being July 13, and the latest August 29. From these data it was assumed that pupation took place about the middle of July with the adults emerging about two or three weeks later.

Eggs laid by the first generation adults were collected August 2 from the upper leaves of ironweed and the larvae hatched three days later. The larvae fed until the last of September before pupating for the winter.

Habits. This species of Arctiidae fed on other plants besides ironweed. Adults in the Kansas State College collection were reared on sunflower, sweet clover, clover, corn, and lamb's quarter.

In the laboratory most of the cocoons were constructed about one-half inch below the surface of the soil, but some larvae pupated in dried leaves on the surface. Only one larva was observed in the act of pupating. This activity required about one day. All the others apparently pupated during the night.

Parasitism. Unidentified dipterous puparia were found inside one acraea coooon.

Lepidopterous larvae. Two species of lepidopterous larvae were observed feeding on ironweed leaves during the summer but adults were not reared. One was a brown humped-back worm more than an inch long with a distinct V-shaped marking on the thoracic tergum. The other was a slender green leaf-roller about one inch long.

Macrobasis immaculata (Say) and Epicauta cinerea (Forst.) Meloidae; Coleoptera.) These two species of blister beetles were observed feeding on V. interior July 18, 1940. Twenty-three individuals had almost completely defoliated the plant on which they were feeding. On other occasions throughout the growing seasons blister beetles were observed and collected from ironweed leaves but usually only one or two specimens at a time.

Conocephalus strictus (Scudder). (Tettigoniidae; Orthoptera.) Nymphs and adults were observed feeding on the upper leaves of the plant. The individuals were present on the weed during June, July, and part of August.

Tettigoniid eggs (species not known) were found inside an ironweed stem and apparently oviposition took place in the autumn. One nymph hatched during the middle of May but further rearing was unsuccessful.

Melanoplus bivitattus (Say) and M. differentialis (Thomas). (Acrididae; Orthoptera.) These hoppers fed on ironweed foliage during July and August. They were attracted to the plant during this period since ironweed was one of the few succulent plants in the pasture because of the dry condition. Two other species of Acrididae, M. confusus Scudder and Chloealtis conspersa Harris were collected from the plant, however, they were not feeding.

Oecanthus nigricornis argentinus Saussure. (Gryllidae; Orthoptera.) All the growth stages of this tree cricket were found associated with ironweed. In August and September the yellow eggs were found inside the stem oviposited in a row characteristic of this insect. Nymphs and adults were collected during June, July, and August. According to Metcalf and Flint (1939) tree crickets feed on the foliage of plants as well as engage in predatious activities.

Stem-consuming Insects

Four curculios, Rhodebaenus tredecimpunctatus Ill., Pantomorus pallidus Horn, Anametis setosus B. & L., and Aulobaris scolopax Say, are known to feed on ironweed. The first two species named were collected during this study and

all four were reported by Blatchley and Leng (1916) as having been taken from ironweed in Indiana. Only a few specimens of the two beetles were collected and only the feeding punctures of R. 13-punctatus were observed.

Rhodobaenus tredecimpunctatus. (Curculionidae; Coleoptera.) Four adults were taken from ironweed near Manhattan during the last of May and first part of June. No other stages were found associated with the plant. Kelly (1931) reported the insect on Xanthium. Blatchley and Leng (1916) gave the following description and note:

> Elongate-oval. Body beneath black; above red with black spots, five on thorax, the median one fusiform, and four on each elytron; the elytral spots often more or less confluent, specimens sometimes occuring with the entire surface black, margined at sides with red. Beak black, two-thirds as long as thorax, sparsely and finely punctate, coarsely so behind the antennae. Club oval, length 7-10 mm.
>
> Common throughout Indiana; April 17-October 6 taken especially in the axils of the leaves of ironweed (Vernonia) in the stems of which it is said to breed. Throughout New Jersey in July. Occurs over the entire United States. Known as the cockle-bur bill bug, as it often breeds in the stems not only of that vile weed and other species of Xanthium but also in those of many other compositae, as joe-pye weed, leaf cup, sunflower, thistle, greater ragweed and rosin weed. Hibernates in the adult stage, the newly bred imagoes appearing in August and September.

Pantomorus pallidus. (Curculionidae; Coleoptera.) Eighteen adults were taken from leaves and stems during June and July. No injury caused by this curculio was observed and no other stage was found. Blatchley and Leng (1916) reported

P. tessellatus Say from ironweed and gave the following description and note:

> Oblong oval...grayish and brownish scales above... length 5-7.5 mm. Vigo County, Ind., scarce; June 19. Four specimens taken from the leaves of ironweed, V. fasciculata Michx. They are apparently of the variety pallidus Horn in which the scales of upper surface are pale greenish white with barely perceptible darker spaces arranged as in the typical variety. Ranges from southwestern, Indiana and Southern Illinois west and southwest to Nebraska and New Mexico. Recorded as attacking sweet potato.
>
> Anametis setosus. (Curculionidae; Coleoptera.) Black densely clothes with dark brown and pearl-gray scales...narrow median stripe on head and beak, length 6-6.5 mm. Described from five specimens taken in Lake Vigo and Posey counties Ind., April 21--July 11, St. Louis, Mo. July 7, Swept from foliage of the ironweed V. fasciculata Michx. (Blatchley and Leng, 1916.)
>
> Aulobaris scolopax. (Curculionidae; Coleoptera.) Dark reddish or chestnut brown; head and under surface darker. Length 3.3-3.7 mm. Frequent throughout southern Indiana, much less so in the northern counties; July 13-September 27; swept from thistle at Dallas, Texas. on July 3. The adults were found breeding on the buds of Baldwin's ironweed, V. baldwinii Torr., and burrowing the heads of Carduus. (Blatchley and Leng, 1916.)

Flower and Seed-consuming Insects

Those insects which fed on the buds, flower parts, and seeds had a direct effect on the propagation of the plant since their feeding reduced the seed production. Ten species representing the families Trypetidae, Phaloniidae, Cecidomyiidae, and Aphididae fed on these parts of ironweed.

Trypetidae. (Diptera.) Five species of Trypetidae were reared from ironweed flowers in eastern Kansas. Neaspilota alba Loew and Tomoplagia obliqua Say were reared in the vicinity of Manhattan and two other species were collected--Neaspilota vernoniae Loew and Trupanea actuangula Thom. In Doniphan county Stewart C. Schell reared five species--N. alba, N. vernoniae, Neaspilota albidipennis Loew, T. obliqua and Trupanea sp.

Species alba, obliqua, albidipennis and vernoniae, were taken from ironweed in Pennsylvania by Osten-Sacken and reported by Loew (1862) under the genus Trypetae.

Injury to Plant. Both species taken by the author, alba and obliqua, were reared from the seeds. The larvae of the first generation began feeding on the ovules about the time the flower buds opened and the full grown larvae of the second generation were still feeding on the seeds in other involucres late in the summer.

In most all cases the feeding activity of the larvae was responsible for the complete destruction of the seeds in each involucre infested. Population studies indicated that one-fourth of the flowers were infested so the seed production of the plant was reduced twenty-five percent by these insects.

Since the chief method of ironweed distribution is by seed production the fact that the trypetids limited the production of seeds made them an important pest of the plant from the economic standpoint.

In late summer the infested involucres were detected in the field by the presence of dry brown flowers which still

Fig. 6. Infested involucres with dried flower parts clinging to the wings of the seeds.

clung to the wings of the partially devoured seeds. (Fig. 6.) Normally in early autumn the involucres opened and the seeds were released but in the case of the flowers which had been infested with the trypetids the opening failed to occur. Although this was of no consequence to the plant since most of the seeds in the involucre had been destroyed anyway, it was of importance to the insect, because it used the protection created by the situation and overwintered within the involucre as a full grown larva.

Abundance. Population studies on this insect were conducted by using 59 stems selected at random from three different pastures. The average stem developed about 130 flowers. One plant had only 26 flowers while another had over 600. Twenty-five percent of the flowers in the field were infested. The higher the flower was located on the plant the more liable it was to be infested. Only a single larva was found in any one flower. Up to 65 percent of the flowers on some stems were infested.

Table 9 indicates that N. alba was about eight times more abundant in the vicinity of Manhattan than T. obliqua but twice as many obliqua were reared as were alba. It also shows that the other three species were scarce.

Table 9. Relative abundance of Trypetidae in two localities in eastern Kansas.

Species	Number of specimens reared	collected	Total
	Manhattan		
N. alba	27	383	410
T. obliqua	50	46	96
N. vernoniae		2	2
T. acutangula		1	1
	Doniphan county		
N. alba	43		43
T. obliqua	74		74
N. vernoniae	6		6
N. albidipennis	1		1
Trupanea sp.	1		1

Several factors influenced the data presented in this table: the time of collection and rearing, the difficulty

with which each was collected, and the rearing technic which may have been more favorable to the development of one insect than the other. However, field observations tended to coincide with the abundance as indicated in the table.

Neaspilota alba. (Trypetidae; Diptera.) Description. The egg was 0.72 mm. long and 0.19 mm. in diameter. It was white, curved slightly, and pointed at one end. The larva was dingy white varying in length from 2 to 3 mm. at maturity. The dingy white pupa was slightly smaller than the mature larva. The adult (Fig. 7.) was whitish with whitish wings and without markings, abdomen yellowish, length of body about 3.5 mm. for the female; male, slightly shorter. (Loew, 1862.)

Life History. This insect passed through two generations each year. The full grown larvae of the second generation overwintered in the involucres. This was possible since the feeding of the maggots prevented the normal development of the flower and as a result the involucres failed to open when the flower matured.

The adults emerged during the latter part of May and June. Oviposition and the opening of the involucres exposing the purple-tipped corollas were almost simultaneous. This usually occurred during the latter part of June and throughout July.

The female alighted atop the flower, thrust her ovipositer down inside the flower, and left the egg lying against the inside of the involucre.

Fig. 7. Neaspilota alba, adult male (top) and female.

Upon hatching the maggots fed on the developing seeds as shown in Fig. 8. They fed for two to three weeks before pupating. The length of time the insect spent within the puparium was not determined but was probably less than a week. The first generation required about a month to complete the life cycle.

Adults of the second generation sought fresh flowers on which to lay their eggs. The majority of the second generation larvae were still feeding by the last of September and went into

Fig. 8. Trypetid maggots feeding on ironweed seeds. Group of seeds at right was not infested.

the winter as full grown individuals. Compared with the first generation populations, the overwintering insects were few in number as a result of the high percentage of parasitism.

Tomoplagia obliqua. (Trypetidae; Diptera.) Description. No eggs were found on the plant but those dissected from the female were similar to those of N. alba. The larva was about same size and color as alba except the last few abdominal segments formed a distinct black plate. (Plate I, Figs. 14 and 15.) The pupa was dingy white and slightly smaller than the mature larva. The adult had a brownish yellow body, with two series of black spots on abdomen. (Fig. 9.) Its wings were

Fig. 9. Tomoplagia obliqua, adult male (top) and female.

yellowish with brownish oblique bands. The body and wings were each about 3.5 mm. in length. (Loew, 1862).

Life History. The data concerning the life history of this species were insufficient to give an accurate idea of the life cycle. It was thought that oviposition took place about the second week in July or later since the earliest collection date for adults was July 14. The larvae from these eggs fed during July and August and the first generation adults emerged about the middle of August. Larvae were found in the flowers as late as the middle of September and it is

Continued on page 43

There is no page 42 in this thesis.

Continued from page 41

supposed that they overwintered as full grown individuals. There was considerable overlapping of generations, adults having been reared continously from August 19 to September 27.

Neaspilota vernoniae. (Trypetidae; Diptera.) This brownish colored fly was slightly heavier than either alba or obliqua, with brownish marks on wings. (Loew 1862.) No data concerning the life history of this individual were secured though the fact that two adults were collected during July from ironweed and that six adults were reared in August indicated that the life cycle of this insect was quite similar to both N. alba and T. obliqua.

Neaspilota albidipennis. (Trypetidae; Diptera.) This adult was similar in size and color to N. alba except it had blackish stigma. Schell reared one specimen of this species from ironweed in Doniphan county, August, 1939. None were found on ironweed near Manhattan.

Trupanea sp. (Trypetidae; Diptera.) One specimen of this genus was reared by Schell in Doniphan county during August.

Trupanea acutangula. (Trypetidae; Diptera.) One adult of this species was swept from ironweed in Pottawatomie county, May 28.

Parasitism. More than 1200 hymenopterous parasites comprising ten families and 22 species, three of which were new, were reared and collected from these typetids. Whether or not all of these species were primary parasites was not determined.

No actual study of the relative amount of parasitism was made. By comparing the number of flies and parasites which

emerged from the same rearing cages it was possible to get some indication of the percentage of parasitism. In this instance it was about 90 percent since only 77 flies of the first generation were reared as compared with 710 parasites.

Even though such a high percentage of parasitism existed, the maggots were still able to bring about a 25 percent reduction of the seed crop. This fact gives some indication of the effect the typetids would have on the plant if the parasites did not tend to hold them in check.

The parasites of the typetid seed maggots are as follows:

Braconidae
Apanteles lunatus (Pack)
Apanteles epinotiae Vier.
Heterospilus languriae (Ashm.)
Microbracon nuperus (Cress)
Rhaconotus n. sp.

Chalcididae
Brachymeria fonscolombei (Dufour)

Cynipidae
Melanips iowensis Ashm.

Elasmidae
Elasmus setosiscutellatus Cwfd.

Eulophidae
Elachertus sp.
Tetrastichus sp.

Eupelmidae
Eupelmus sp.
Eupelmus allynii (French)

Eurytomidae
Eurytoma n. sp.
Eurytoma n. sp.
Eurytoma sp.

Mymaridae
Gonatocerus sp.
Polynema caesariatipenne Gir.
Polynema bifasciatipenne varium Gir.

Pteromalidae
Catolaccus kansensis Gir.
Habrocytus purpureiventris (Ashm.)

Chalcidoidea
Amblymerus sp.
Zaglyptonotus schwarzi Cfwd.

Most of the parasites emerged during August and September which was the time that the first generation adults were present. Most of the parasites of the first generation emerged shortly after the puparia were formed. A total of 42 specimens were reared in May, and ten were collected during June and July.

Three species, Eupelmus allynii, Tetrastichus sp., and Eurytoma n. sp. were also reared from the cecidomyiid galls. E. allynii is known to be a parasite of the Hessian fly and other crop pests.

A list of other parasitic insects which were collected from ironweed is included in Table 6.

Cecidomyiidae; (Diptera.) The two gall midges which formed galls on ironweed blossoms and buds are discussed in this paper in the section dealing with burrowing insects and gall-makers.

Phaloniidae. (Lepidoptera.) Several adults of an unidentified species of the genus Phalonia was reared from ironweed flowers by S. C. Schell in Doniphan county, Kansas, in August and adults and larvae of the same species were collected from ironweed near Manhattan in May, July, and August. The moths were brownish gray and less than one centimeter long. The larvae fed on the flowers, seeds, and involucres during July and August. There seemed to be only one generation each year.

Phalonia rana Busck has been reported from ironweed, according to Klots[2], who made the determinations of some of the lepidopterous material from Kansas ironweed, but the species concerned was not rana, rather being nearer species aurorana Kearfott or zoxana Kearfott.

Sucking Insects

Actually only a few species of insects have been observed extracting plant juices from ironweed. Since it is difficult to observe the feeding activity of such insects, it is quite probable that many other species which have been collected from the plant fed in this manner without being observed.

Aphididae, Cercopidae, Membracidae, and Pentatomidae are known to feed on the plant and species representing families Cicadellidae, Coreidae, Lygaeidae, Piesmidae, and Miridae were collected from V. interior. None of the species seem to be abundant and no injury to plants growing near Manhattan was evident.

Aphididae. (Homoptera.) Two species of aphids were found feeding on ironweed. Aphis vernoniae Thomas fed on the buds, petioles, leaves and stems while Prociphilus sp. fed on the roots and the stems just below the crown.

Aphis vernoniae. (Aphididae; Homoptera.) These bright yellowish aphids were collected from ironweed during July and

---

2 Personal correspondence from Mr. A.B. Klots, department of Biology, College of the City of New York. April 3, 1940.

August. Sanborn (1904) found this species on Vernonia in July and indicated that it was gregarious and colonized on the terminal growth.

The ants associated with the aphids were identified as Cremastogaster opaca punctulata Em., Cremastogaster lineolata subopaca Em., Cremastogaster sp., Dorymymex sp., Leptothorax pergandei Em., and Prenolepis imparis (Say).

Prociphilus sp. (Aphididae; Homoptera.) Nymphs of this genus were collected on the roots of ironweed in late August and September 1939 and in April 1940. They were dingy white in color and their burrows in the soil were lined with powdery material. No winged forms were collected. According to Wadley[3] who made the determinations of the aphids taken from ironweed during this study, P. erigeronensis Thomas would be expected to be found on the roots of composites in Kansas but the species on V. interior, was not erigeronensis.

The following aphids and the species of Vernonia on which they fed were listed in the Food-Plant Catalogue of Aphids of the World (Patch, 1938).

Anauraphis helichrysi Kaltenbach	V. chinensis
Aphis	
gossypii Glover	V. chinensis
malvoides Van der Goot	V. arborae
middletonii Thomas	V. fasciculata
spiraecola Patch	V. sp.
vernoniae Thomas	V. fasciculata, augustifolia

3 Personal correspondence from Mr. F. M. Wadley, Bureau of Entomology and Plant Quarantine, Washington, D.C. February 3, 1940.

Macrosiphum	
minutum Van der Goot	V. cinerea
redbeckiae Fitch	V. fasciculata, lindheimeri, noveborancensis
solidaginis Fab.	V. arborea, chinensis.

Micrutalis calva (Say). (Membracidae; Homoptera.) This small green homopteron with a shiny black pronotum was collected during the summer months on ironweed near Manhattan but was not observed to be very abundant nor was any injury caused by its feeding on the stem apparent.

Schell reared a number of individuals on V. interior in Doniphan county, Kansas, reported they were numerous, and that injury to the plant was observed.[4]

Collections of adults and nymphs indicated that there were at least two generations each year. Adults of its first generation appeared about the middle of July and those, that eventually overwintered, appeared during the latter part of August and first part of September.

Aphrophora quadrinotata Say. (Cercopidae; Homoptera.) Spittle bug nymphs were observed on ironweed during May and the first part of June. They were found in froth masses on the stem several inches above the surface of the ground. The determination was made from nymphs only.

Euschistus variolarius (P.B.). (Pentatomidae; Hemiptera.) Adults of this stink bug were collected on the plant during July

---

4 Personal correspondence from Mr. S. C. Schell. November 23, 1939.

and August. The exact nature of the relationship of this insect to ironweed or to other insects on the plant was not determined.

However, pentatomid eggs were found on the leaves and nymphs which hatched from these eggs fed on plant juices in the leaves. Since no adults were reared from these individuals their identity was not learned.

Burrowing Insects and Gall-makers

The ten species which fed inside the stems of V. interior were responsible for a greater amount of damage to the plant than any other group of insects associated with it. By the end of the growing season stems were hollowed out and weak as a result of the feeding of the borers. These insects represented dipterous families Cecidomyiidae, Trypetidae, and Agromyzidae; coleopterous families Cerambycidae and Mordellidae; lepidopterous families Noctuidae and Aegeriidae.

Cerambycidae. (Coleoptera.) Two members of this family, Ataxia hubbardi Fisher and Hemierana marginata ab. ardens (Lec.), burrowed in the stems. Another individual, Hippopsis lemniscata (F.), was found inside a burrow in an ironweed stem but since it was taken only once its association with V. interior must be unusual. Kelly (1931) reported that A. hubbardi and H. lemniscata fed in stems of Xanthium.

Ataxia hubbardi. (Cerambycidae; Coleoptera.) Description. The egg was not found. The larva was whitish with dark brown

mandibles. When full grown it averaged about 2-3 mm. in diameter and 18 mm. in length with some individuals 24 mm. long. The pupa was bare and slightly shorter but thicker than the mature larva. The adults were reddish-brown with some lighter marking on the elytra and varied from 10 to 14 mm. in length. (Fig. 10.)

Fig. 10. Adults of stem borers. Ataxia hubbardi (left) and Hemierana marginata ab. ardens.

The larva of A. hubbardi was distinguished from the larva of H. marginata by the presence of a fleshy spine on the tip of the abdomen as shown in Plate I, Figs. 16 and 17. The early stages of the borers did not exhibit this character.

Injury to Plant. Eggs were laid either on or within the stem slightly more than half way up on the plant and the young larvae entered the pith to feed about the last of June or the first part of July. They burrowed downward through the pith making an irregular spiral path as shown in Fig. 11.

It required from six weeks to two months for the borers to reach the crown of the plant. No burrows made by these larvae were observed to extend below the crown. Since by the time the borers reached the crown most of the pith in that region was consumed, they usually retraced their burrows and enlarged them. Feeding continued until late in September or the first part of October. The larvae in small stems fed to the extent that only the hard outer tissues of the stem remained when their feeding activity ceased for the season. In these stems the larvae tended to burrow as high in the plant as their own size allowed.

Since the borers fed only in the pith for the major part of the growing season, it is thought that little injury resulted from their feeding activities. It was possible, however, that seed production and food storage was affected when there was sufficient feeding in the conductive tissues of the stem.

Abundance. Fifty-one A. hubbardi and H. marginata larvae were found in 128 stems selected at random from several pastures during the growing season. No effort was made to separate the larvae of the two species in making the survey. This sample indicated that about 40 percent of the plants were

hosts to the cerambycid borers. There was only one borer in each infested stem.

Of the 33 larvae and pupae which were brought into the laboratory and reared successfully all except four were A. hubbardi. This was the only data that indicated the relative abundance between the two species.

Life History. Although no eggs were found, they were probably laid on the plant about the last of June since young larvae were found in the stem as early as the second week in July. The larvae fed until the last of September or the first of October and overwintered in the base of the stem as full grown individuals. The burrow was plugged with frass above and below the larva to form its overwintering quarters. Pupation occurred during the last of April and the first of May. The average length of time for the pupal stage in the laboratory was about 15 days.

Hemierana marginata ab. ardens. (Cerambycidae; Coleoptera.) Description. The egg was not found. Full grown larva averaged about 15 mm. in length and 1.5-2.0 mm. in diameter; white abdomen, yellowish head and thorax with dark brown mandibles. The bare pupa was slightly smaller than the larva. The adult was black with orange markings on the thorax. (Fig. 10.)

Injury to Plant. The feeding habits and life history of this species was similar to that of A. hubbardi. Since it was smaller in size it probably caused less injury to the plant than the later.

Fig. 11. Longitudinal sections of ironweed stems showing burrows of *Ataxia hubbardi* and *Hemierana marginata*. Stem at right was not infested.

Abundance. Only one-seventh of the long-horned borers reared were marginata. If this figure is a good indication of the population, only about five percent of the plants were infested by this species.

Life History. The life history closely paralleled that of A. hubbardi. The full grown larva passed the winter in the base of the ironweed stem where it sealed itself into a limited space as indicated in Fig. 12. In the spring pupation took place in this cell and the adult emerged in May.

One larva was brought into the laboratory March 3 where it pupated 24 days later, and the adult emerged April 3. This record does not correspond with pupation and emergence dates in the field. Another individual was taken into the laboratory April 19 where it pupated April 28 and emerged ten days later. Other pupae were collected May 15 and adults emerged within the next ten days. In the field the pupation took place the last of April and the first part of May; emergence occurred within the subsequent ten to 14 days.

Adults were collected on the plant during June and larvae of the following generation taken from their burrows about the middle of July.

Parasitism. One parasite, Monogonogastra agrili (Ashm.) (Braconidae), was reared from pupae of these borers in May. It was not determined which species of borers was parasitized but both species were probably attacked. Six hyperparasites identified as Merisus n. sp. (Pteromalidae) emerged May 26,

Fig. 12. Longitudinal section of ironweed stem showing Hemierana marginata in its burrow which was plugged above and below larvae to form an overwintering chamber. (Puparium just above larva is that of Agromyza sp.)

from a primary parasite of the stem borers belonging to the genus Iphiaulax (Braconidae).

Only six parasites were found in the field. In each instance a silky cylindrical cocoon about one inch long was formed about the parasitized pupa.

The percentage of parasitism seemed to be relatively low.

Hippopsis lemniscata. (Cerambycidae; Coleoptera.) Blatchley (1910) gave the following description and note:

> Elongate, very slender, cylindrical, dark reddish brown; thorax with two white lines each side; elytra each with three whitish lines...antennae more than twice as long as body...length 10-13 mm. May 28--June 7. Breeds in stems of ragweed (Ambrosia); also in tickweed and bur-marigold (Coreopsis and Bidens.)

The one larva of H. lemniscata collected in November from its hibernation quarters in a V. interior stem was 13 mm. long and 1.5 mm. in diameter; head and prothorax pale yellow and rest of body whitish, brown hairs were present ventrally and on last abdominal segment.

Mordellidae. (Coleoptera.) Four species of this family were associated with ironweed, Mordella insulata Lec., Mordellistena sericans Fall, M. pustulata Melsh., and Mordellistena sp.

Only M. pustulata was reared from the stems. Adults of this species were collected in large numbers.

Mordellistena pustulata. (Mordellidae; Coleoptera.) Description. The larva was from 7-9 mm. long when full grown and about 1.0 mm. in diameter. Body was white to creme colored with a yellowish head capsule and dark brown mandibles. The

bare pupa was white to yellow and about the same size as the larva. Adults were 2-3 mm. in length, black, with elytra spotted with silvery pubescence.

Injury to Plant. Although these larvae were numerous they probably did not cause serious injury to the plant. Their crooked, winding burrows (Fig. 13.) were usually found in the upper two-thirds of the stem and varied in length from 5 to 29 inches with an average of 18 inches. The maximum burrow width was 2 mm. with the major portion of the burrow about one-half this size. For most of its length the burrow was filled with light colored frass. The larvae started feeding in the upper part of the stem and some of them gradually worked downward to within several inches of the crown by the end of the growing season.

Abundance. Of 103 stems inspected near the end of the growing season 99 were hosts to at least one borer. Usually there were more than one and the maximum was seven. Two hundred and ten larvae were taken from the 103 stems which indicated the average population was about two per plant.

Life History. The larva overwintered in its burrow in the pith usually in the lower half of the stem. It pupated in the spring in the stem and the adult emerged during May. There was only one generation each year.

No eggs were found but they were probably inserted in the stem during June, since the adults were most abundant about that time. By tracing the burrows of young larvae it was determined

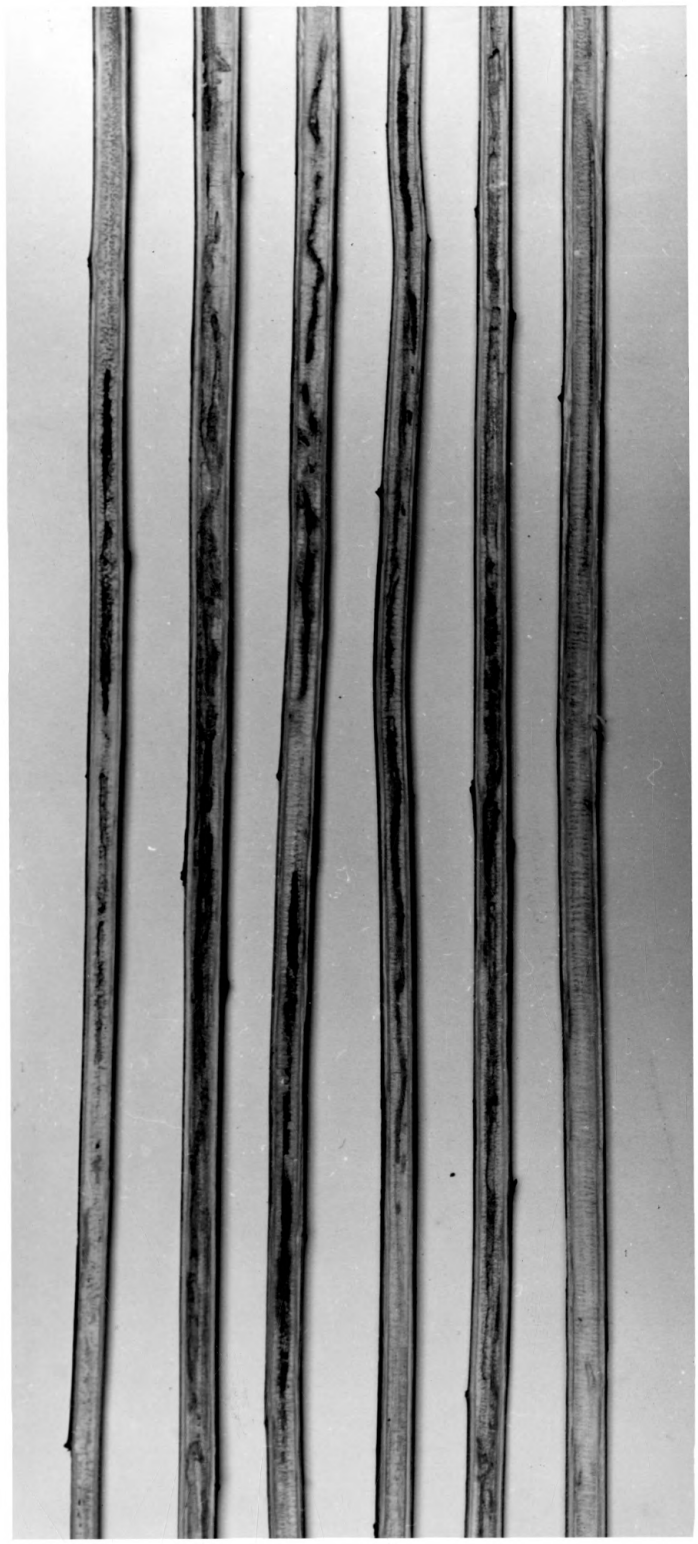


Fig. 13. Longitudinal sections of ironweed stems showing burrows of Mordellistena pustulata. Stem at right was not infested.

that the eggs were laid just below the junction of the petiole with the stem. As a result of oviposition a tiny brown scar was left in the stem. There was some indication that eggs were laid in the petioles and in the midrib since burrows could be retraced to those structures. The earliest date that larvae were taken from the stems was the first week in July.

Parasitism. Forty individuals of the genus Schizoprymnus (Braconidae) were reared from M. pustulata pupae. According to C. F. W. Musebeck who made the determinations of these specimens, they were apparently undescribed. The only indication of the percentage of parasitism was the fact that four times as many parasites were reared as were beetles. The emergence of the parasites was simultaneous with the emergence of the adults.

Agromyza sp. (Agromyzidae; Diptera.) Larvae identified as members of Agromyza sp. burrowed in the stem. No adults were reared, consequently, the species was not learned.

Description. The larva was whitish, slightly curved, about 6 mm. long and 0.8 mm. in diameter with two black hooks on the end of the abdomen. (Figs. 19 and 20.) The puparium was light brown in color, 4 mm. long and 1 mm. wide. No adults or eggs of this species were taken.

Injury to Plant. The feeding of this borer resulted in a rather straight burrow down through the center of the pith. (Fig. 20.) The burrows usually started about half way up the plant and terminated at the crown, varying from 12 to 24 inches in length. The maximum width of the burrow was 3 mm. These insects fed only about 30 to 40 days and caused little injury.

Explanation of Plate I

Fig. 14. Caudal aspect of *Neaspilota alba* Loew larva.

Fig. 15. Caudal aspect of *Tomoplagia obliqua* Say larva.

Fig. 16. Side view of tip of abdomen of *Ataxia hubbardi* Fisher larva.

Fig. 17. Side view of tip of abdomen of *Hemierana marginata* ab. *ardens* (Lec.) larva.

Fig. 18. Side view of *Agromyza* sp. larva.

Fig. 19. Caudal aspect of *Agromyza* sp. larva.

PLATE I

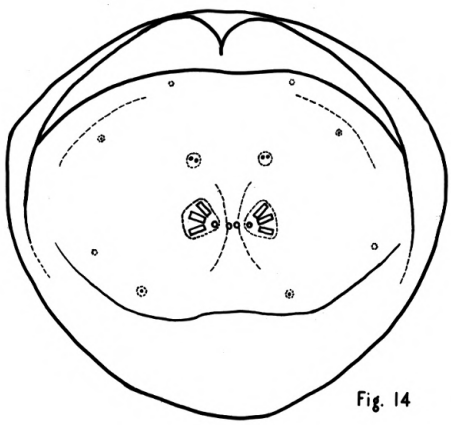


Fig. 14

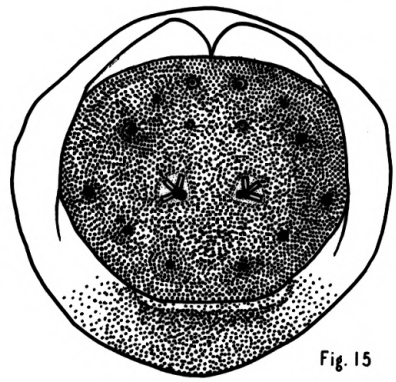


Fig. 15

Fig. 16

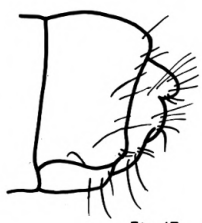


Fig. 17

Fig. 18

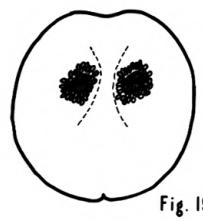


Fig. 19

Fig. 20. Longitudinal sections of ironweed stems showing burrows of Agromyza sp. Stem at right was not infested.

Abundance. Based on the population studies of 128 stems this species was present in only 12.5 percent of the cases. Usually there was but one individual per stem.

Life History. There was only one generation each year and the mature larva overwintered in the puparium which was formed about the middle of July. No eggs were found and the early stages of the larvae were not taken so the time of emergence and oviposition was not learned. Since no larvae were found in the stems in May, but mature larvae were found the first week in July and puparia by July 12, it is thought the adults probably emerged the latter part of May and the larvae hatched early in June. Three species of Agromyza adults were collected from V. interior in May but whether or not any of these individuals were adults of the borer concerned was not determined.

Lasioptera vernoniae Beutm. (Cecidomyiidae; Diptera.) This midge was reared from ironweed stem galls during April and May.

Description. No eggs were found. The larva was about 2.5 mm. long and 0.5 mm. in diameter. Beutenmuller (1907) gave the following description of the larvae:

> Yellow. Body slender and elongate. Terminal segment rounded without any projection. Anchor process or breast bone long and slender, gradually increasing in width from base to the apex which has two lateral teeth and short median one.

The adult was gray with a yellowish-brown abdomen. The male was 1.5 mm. long and the female 1.7 mm. long.

Injury to Plant. Oviposition probably occurred during May or first part of June since adults emerged from the stems in April and May and the galls were well formed by July. The larvae entered the pithy portion of the stems where the galls formed about them. Sometimes single cells were distributed along the stem but often a large number of galls developed in a small space which caused a noticeable enlargement of the stem, often so great that splitting of the stem occurred. (Figs. 3, 4, and 5.)

Even when splitting did not occur, a large number of galls in a small space caused the stem to become brittle and under such conditions the passage of nutrient materials through the stem was probably hindered. The only evidence to substantiate this was the fact that many of the stems which were deformed with a large number of galls developed only a few flowers.

Galls were also found on the petioles of the plant. Beutenmuller (1907) reported this midge from midrib galls and according to Painter (1935) the galls occurred on the stems, midribs, petioles, and receptacles of the flowers.

Beutenmuller (1907) gave the following description of the midrib gall:

> Green, sometimes tinged with red, rounded or elongate and of the texture of the stem of the plant. Inside it is soft, fleshy, and contains a single larva in an elongated channel. Length about seven to 12 mm. width 5-7 mm. When dry the gall becomes brown and pithy inside and somewhat resembles a cherry pit. It is usually situated near the midribs of the leaves of ironweed, Vernonia noveboracensis.

The only galls observed during this study which compared with the preceding description were those which occurred on the petioles.

Painter (1935) reported the following concerning galls caused by this insect on V. interior in Texas.

> The galls vary greatly in shape and occur on the stem, midrib, petiole, and the receptacle of the flower. They are polythalmous, cylindrical, the larvae feeding in the pith. Stem galls are usually 30x10 mm; the midrib swellings 25x5.

Various examples of the shapes of galls are shown in Figs. 3 and 4 and a close up of individual galls are shown in Fig. 21.

Abundance. During the summer of 1940 examination was made of 128 stems. Seventy stems or 57 percent were infested with galls. There was a total of 793 galls in the 73 stems or about 11 galls per stem. The number of galls in a single stem varied from one to 54.

Life History. The full grown larva passed the winter inside the gall in the stem of the plant. Adults emerged in the spring as soon as weather conditions were favorable. One of the most important factors for their emergence was moisture. The outer tissues of the stem dried to form a hard rind and until this was softened it was impossible for the midges to push through it.

The early part of the spring of 1940 was relatively dry in Manhattan, consequently, the midges did not emerge in the field until the first part of May. Stems were taken into the

Fig. 21. Longitudinal sections of three galls of Lasioptera vernoniae. Stem at left shows larva within the gall.

greenhouse and provided moist conditions. From these stems midges emerged as early as the first of April.

Other stems were collected during April but no emergence was observed until the first week in May. Adults reared in the greenhouse were placed on young ironweed plants. Several alighted on the plants as soon as they were placed in the cages and went directly to the stems. Although some of the midges went through motions which indicated they were in the act of oviposition, no eggs could be found in the stems when they were removed from the cages and examined shortly afterward.

Since no observations were made of the galls during the month of June no data relative to the rapidity of their development were secured. By the first week in July the galls were well formed and were almost full size. During the summer they became harder but otherwise no additional change was observed. About the middle of July the larvae began to assume their yellow or orange color, and apparently had reached their maximum growth.

Parasitism. Two hundred and forty-seven hymenopterous parasites were reared and collected from the galls, comprising eleven species, five of which were new. The list of parasites is as follows:

Braconidae
- new genus and new species
- Iphiaulax sp.
- Trichacis rubicola Ashm.
- Trichacis rubicola var.

Platygasteridae
- Platygaster sp.

Callimomidae
Callimome n. sp.
Callimome n. sp.

Eupelmidae
Eupelmus allynii (French)

Eurytomidae
Eurytoma n. sp.
Eurytoma n. sp.

Eulophidae
Tetrastichus sp.

Only 95 specimens were reared from the galls during July and August. The other emerged in April and May simultaneous with the emergence of the midges. Tetrastichus sp., Eupelmus allynii, and Eurytoma n. sp. were also reared from the trypetids that fed on the seeds.

No actual study was made to determine the abundance of the parasites. The only data which might indicate this were the comparison of the numbers of midges reared to the number of parasites. During April and May approximately the same number of parasites emerged as did midges which was 50 percent parasitism. However, since other parasites emerged during the growing season of the previous year the percentage of parasitism is greater than indicated by this comparison.

Painter (1935) reported that the midges were heavily parasitized.

Youngomyia vernoniae Felt. (Cecidomyiidae; Diptera.) This midge was not collected during this study nor were any galls which might have been caused by this insect observed on the plant. According to Felt (1911) the male was 2 mm. long,

yellowish-brown with hyaline wings and the female was 2.5 mm. long, varying from reddish-brown to yellowish-brown. The specimens which were described by Felt, were reared from blossoms of V. noveboracensis in Virginia.

Asphodylia vernoniae Felt. (Cecidomyiidae; Diptera.) This midge was reported by Felt (1918) as having been reared from buds of ironweed and was described by Felt (1916). None of the midges were collected during this investigation.

Eutreta sparsa Wied. (Trypetidae; Diptera.) This gall-forming fly was not taken during this study but was reported by Painter (1935) on ironweed in Texas as follows:

> Hosts: Ratibida columnaries D. Don., cone flower and Vernonia interior Small.
> The gall occurs on the stems of both hosts and in Vernonia is an oval swelling 6x10 mm. in size often tinted with purple. The galls are present from early April through May. Adults from both hosts emerged in cages, April 20 to May 30. It appears probable that the insect overwinters in a gall in the crown of the plant. Galls were more abundant on Ratibida than on the other host.

Compositicola bassiformis (Wlk.). (Aegeriidae; Lepidoptera.) None of the life stages of this clear wing moth were found associated with ironweed during this investigation, however, R. H. Painter, and G. P. Englehardt have taken this insect from Vernonia in Kansas.

Beutenmuller (1901) gave a description of the insect and note of its habits as follows:

> Male.--Head and thorax metallic bronzy black--- with distinct yellow lines on each side. Abdomen narrow, violet brown black, narrow yellow rings on first to fourth inclusive and sixth and seventh segments...

> Female.--much heavier...Abdomen only five yellow bands...anal tuft yellow.
> Expanse. Male 18-20 mm. Female 22-26 mm.
> Habitat. New York, Mass., southward to Texas and westward to Nebraska, and Colorado.
> A well marked species readily known by gold bronze maring of fore wings and by the bright yellow band on the abdomen. The larva lives in the stems of trumpet weed (Eupatorium purpureum.)

According to Engelhardt[5] this borer "resembles the larvae of Pyrausta oxydalis in color, make up, and size and bores in the same parts of the plant. It pupates within the gallery in a rough oblong cocoon of chips. The adults here in the east emerge during August and early in September; in Kansas perhaps a week or two earlier."

Papiapema cerrusata G. & R. (Noctuidae; Lepidoptera.) No specimens of this species were taken on ironweed during this study but Engelhardt[6] stated:

> This noctuid bored in the upper part of the stem, working downward gradually with openings at intervals for throwing out frass. They burrowed down to the crown or even beyond. Pupation during September took place, normally in surrounding soil. It is a typical noctuid larva with sparse hairs and faint lateral lines and scattered blackish spots, especially at the spiracles. Full grown larva should be one and one-half or more inches in length.

Acromyctinae. (Noctuidae; Lepidoptera.) One larva of this subfamily was found within an ironweed stem partially devoured by a carabid larva.

---

[5] Personal correspondence from Mr. G. P. Engelhardt, Brooklyn Entomological Society, February 9, 1940.

[6] See footnote [5].

Pyrausta oxydalis Gn. (Pyralididae; Lepidoptera.)

Description. Eggs of this species were not found. The larva was whitish with a reddish brown head capsule; a full grown individual being about 18 mm. long and 2.0 mm. in diameter. It had four pair of prolegs with conspicuous black crochets which formed a complete ring. Adults were not reared or collected during this investigation but have been reared from roots of ironweed by Engelhardt.[6]

Injury to Plant. This borer fed in the crown and the roots of the plant. The maximum height to which it burrowed up the stem was one or two inches above the crown but most of its feeding took place in the underground stem and roots. The larvae were present in the stems as early as the first week in July and in the roots as late as the last week in May of the following year. Some burrows were about 10-12 inches long.

The detrimental effect of this injury to the crown and roots of the plant was not determined for certain but it was thought to be a limiting factor to the development of new shoots from the root stalks in the spring.

Abundance. Only a limited population study was made but it was observed that there was much variation in the abundance of this species in different localities. In some pastures these borers were found in nearly every plant while in other places very few larvae could be found. Only 24 borers were found in the 128 stems examined during 1940. This was about

---

[6] See footnote[5] page 69.

19 percent infestation. Only one insect was found in any one stem.

Life History. By tracing the burrow of a young larva indications were that the egg was laid on the outside of the stem just above the surface of the ground. Young larvae were found near the crown in July. During the growing season most of the feeding of the borers took place near the crown but toward the end of the summer they had burrowed almost through the stem just above the crown thus providing an exit for the adult to emerge the following spring.

In late autumn as the borer worked its way toward the roots, it constructed several plugs across its burrow. In so doing the insect walled itself off from the crown above it. Feeding was resumed in the spring in the roots and pupation and emergence probably occurred in June.

Predatism. Ground beetle larvae were found several times in the burrows of this species with the remains of their prey. The species of the predator was not determined.

Root-consuming Insects

Prociphilus sp. (Aphididae; Homoptera.) This aphid was found feeding on the roots and is discussed in this paper under Sucking Insects.

Pyrausta oxydalis Gn. (Pyralididae; Lepidoptera.) The larvae of this species burrowed in the crown and roots of

ironweed and it is discussed in the preceding section, Burrowing Insects and Gall-makers.

Reticultitermes sp. (Termitidae; Isoptera.) Termite workers were found in the roots and crown of ironweed on three occasions, April, May, and August. Whether they were working in burrows made by the root borer (P. oxydalis) or ones of their own construction was not determined.

Phyllophaga sp. (Scarabaiidae; Coleoptera.) White grubs were found feeding on roots of ironweed on several occasions. They were thought to have been a species of Phyllophaga and possibly the wheat white grub P. lanceolata (Say) since adults of the later species were collected on ironweed in June.

Melanotus sp. (Elateridae; Coleoptera.) One wireworm of the genus Melanotus was observed feeding on roots of the plant in April and an adult of the same genus was collected from ironweed in August.

Other Insects Associated with Ironweed

Table 10 lists insects which have been collected from Vernonia interior. Nothing is known about the relationship of these insects to the plant except they were swept from it during the growing season.

Table 10. A list of insects collected from Vernonia interior.

Order	Family	Species	Date of collection: May 26	May 28	June 9	June 15	June 22	July 7	July 9	July 15	July 18	July 20	July 31	August 8	August 12	August 19	August 21	August 24	August 27	August 29	Sept. 1	Sept. 4	Sept. 7	Sept. 12	Sept. 20	Tot.
ORTHOPTERA																										
	Tettigoniidae																									
		Amblycorypha oblongifolia (DeG.)									1		2													3
		Neoconocephalus sp.									1															1
		Orchelimum sp.							2			1														3
COLEOPTERA																										
	Histeridae																									
		Phelister subrotundus (Say)		1																						1
	Cantharidae																									
		Cantharis sp.		1																						1
	Melyridae																									
		Collops quadrimaculatus(F.)		1																						1
	Cleridae																									
		Hydnocera pubescens Lec.							1		1		13	1			5			9						30
	Mordellidae																									
		Mordella insulata Lec.							5																	5
		Mordellistena sericans Fall		1		7																				8
		Mordellistena sp.							1	1																2
	Meloidae																									
		Zonites bilineata Say															1									1
	Elateridae																									
		Melanotus sp.											1													1
	Buprestidae																									
		Acmaeodera pulchella (Hbst.)											2	1	1			1	9							14
	Dermestidae																									
		Attagenus sp.			1																					1
	Cerambycidae																									
		Tetraopes tetraophthalmus (Forst.)			4																					4
		Mecas inornata (Say)				1																				1

Table 10. Continued.

Order	Family	Species	Date of collection: May 26	May 28	June 9	June 15	June 22	July 7	July 9	July 15	July 18	July 20	July 31	August 8	August 12	August 19	August 21	August 24	August 27	August 29	Sept. 1	Sept. 4	Sept. 7	Sept. 12	Sept. 20	Tot.
	Chrysomelidae																									
		Aphthona texana Cr.							1																	1
		Cryptocephalus quadrimaculatus Say			1	1																				2
		Diabrotica longicornis (Say)												1				1	4							6
		Diabrotica 12-punctata (Fab.)													2			2	2		1					7
		Glyptina sp. prob. spuria Lec.								1																1
		Metriona sp. prob. atripes (Lec.)												1												1
		Oedionychis sp. prob. miniata (F.)	1																							1
		Pachybrachis sp.	1	4	4	3				1								1	2							15
		Zygograma saturalis (F.)							6																	6
	Anthribidae																									
		Brachytarsoides sp.																		1						1
	Curculionidae																									
		Apion oblitum Smith				1																				1
		Baris sp.								1																1
		Centrinaspis sp.													1											1
		Conotrachelus leucophaeatus Fahr.																	1							1
		Epicaerus imbricatus Say	1	1							1															3
		Pseudobaris farcta Lec.								1				1		1		6	12							21
		Smicronyx fulvus Lec.													3			3	2							8
		Smicronyx sp.													6											6
HEMIPTERA																										
	Cydnidae																									
		Galgupha ovalis Huss.						1																		1
	Pentatomidae																									
		Homaemus bijugis Uhl.											1													1
		Podisus maculiventris (Say)						1																		1
		Thyanta custator (F.)							1	1				1	1				1							5
		Thyanta accerra McA.	1											1												2

Table 10. Continued.

Order	Family	Species	Date of collection: May 26	May 28	June 9	June 15	June 22	July 7	July 9	July 15	July 18	July 20	July 31	August 8	August 12	August 19	August 21	August 24	August 27	August 29	Sept. 1	Sept. 4	Sept. 7	Sept. 12	Sept. 20	Tot.
	Coreidae																									
		Coriscus pilosulus (H.S.)						1																		1
		Corizus hyalinus (F.)													1			2								3
		Corizus hyalinus var.												1		1		4	1							7
	Lygaeidae																									
		Blissus leucopterus Say	1																7						15	23
		Lygaeus kalmii Stal.	2		1																					3
		Nysius ericae (Schill.)				1																				1
		Orthaea basalis (Dall.)						1																		1
	Reduviidae																									
		Aristus cristatus Linn.						1																		1
		Sinea diadema Fab.						2									1									3
	Nabidae																									
		Nabis alternatus Parsh.	1																							1
	Anthocoridae																									
		Orius insidiosus (Say)																	8		2			1		11
	Miridae																									
		Adelphocoris rapidus Kn.								1	5			2	1				2							11
		Ceratocapsus fuscosignatus Kn.								7																7
		Horcias dislocatus nigritus Reut.	1																							1
		Lygus pratensis (Linn.)						1		8	1			1	2				1							14
		Melanotrichus coagulatus (Uhl.(	1																							1
		Polymerus basalis (Reut.)								1				1												2
		Psallus seriatus (Reut.)	1																							1
	Neididae																									
		Jalysus spinosus (Say)			1																					1
	Piesmidae																									
		Piesma cinerea (Say)	21							10																31

Table 10. Continued.

Order	Family	Species	Date of collection: May 26	May 28	June 9	June 15	June 22	July 7	July 9	July 15	July 18	July 20	July 31	August 8	August 12	August 19	August 21	August 24	August 27	August 29	Sept. 1	Sept. 4	Sept. 7	Sept. 12	Sept. 20	Tot.
HOMOPTERA																										
	Cicadellidae																									
		Acertagallia uhleri (Yand.)								5																5
		Cicadella hieroglyphica (Say)	1							2																3
		Draeculacephala mollipes Say		2						1																3
		Platymoideus acutus (Say)						1		4																5
		Platymoideus cinereus (Osb. & Ball)								3																3
		Nasutoideus frontalis (V.D.)		1						2				2												5
		Polyamia inimicus (Say)	46							9																55
		Laevicephalus minimus (Osb. & Ball)						1																		1
		L. spicatus Delong		1	2																					3
		L. striatus (L.)		1						1																2
		Exitianus obscurinervis (Stal.)								5																5
		Norvellina chenopodium (Osb.)								2				1												3
		N. seminudus (Say)								3																3
		Phlepsius irroratus Say																1								1
		Phlepsius sp.						1																		1
		Chlorotettix spatulatus (O.&B.)								12																12
		Macrosteles divisus (Uhl.)	15							1																16
		Balclutha abdominalis (V.D.)	13																			2				15
DIPTERA																										
	Chironomidae																									
		Anatopynia sp.		3																						3
	Bombyliidae																									
		Systoechus vulgaris Lw.													1	5		1	1	2						9
	Therevidae																									
		Psilocephala haemorrhoidalis (Macq.)									1															1

Table 10. Continued.

Order	Family	Species	Date of collection: May 26	May 28	June 9	June 15	June 22	July 7	July 9	July 15	July 18	July 20	July 31	August 8	August 12	August 19	August 21	August 24	August 27	August 29	Sept. 1	Sept. 4	Sept. 7	Sept. 12	Sept. 20	Tot.
	Empididae																									
		Platypalpus sp.		20																						20
	Dolichopodidae																									
		Gymnopternus sp.																		2						2
		Psilopus silpho (Say)							2																	2
	Asilidae																									
		Asilus mesae Tucker								1																1
	Helomyzidae																									
		Leria sp.		1																						1
	Borboridae																									
		Sphaerocera sp.		1																						1
	Sapromyzidae																									
		Camptoprosopella sp.		3																						3
		Sapromyza sp.																						1		1
	Trypetidae																									
		Carphotricha culta Wied.								2	2															4
	Sepsidae																									
		Sepsidimorpha secunda Mell.		1																						1
	Ephydridae			1																						1
	Chloropidae																									
		Anthracophaga declinata Beck	2	1																						3
		Chlorops 5-punctata Lw.	47																			3				50
		Chloropisca glabra (Mq.)	1																							1
		Gaurax sp.		1																						1
		Madiza sp.																		1						1
		M. cinerae (Lw.)		1																						1
		Meromyza americana Fitch	2							1																3
		Oscinella sp.		1																1						2

Table 10. Continued.

Order	Family	Species	Date of collection: May 26	May 28	June 9	June 15	June 22	July 7	July 9	July 15	July 18	July 20	July 31	August 8	August 12	August 19	August 21	August 24	August 27	August 29	Sept. 1	Sept. 4	Sept. 7	Sept. 12	Sept. 20	Tot.
	Agromyzidae																									1
		Agromyza sp.		1																						1
		Agromyza.sp.		1																						1
		Agromyza sp.		1																						1
		Cerodontha denticornis (Panz.)	1																							1
	Anthomyiidae																									
		Hylemya sp.		3	22				1																	26
	Muscidae																									
		Musca domestica (L.)							2																	2
		Stomoxys calcitrans (L.)							1																	1
	Sarcophagidae																									
		Sarcophaga stimulans Wlk.								14							1		1							16
	Tachinidae																									
		Anachaetopsis tortricis Coq.	1																							1
		Hyalomya sp.		1																						1
		Paradidyma sp.		1																						1
		Zenillia sp.		1																						1
HYMENOPTERA																										
	Argidae																									
		Arge humeralis (Bea.)		1																						1
	Cynipidae																									
		Eumayria sp.		1																						1
	Eurytomidae																									
		Harmolita grandis Riley	1																							1
	Mutillidae																									
		Timulla vagans vagans																	1							1
	Tiphiidae																									
		Tiphia intermedia Mall.																2								2
	Formicidae																									
		Sysphincta pergandei Em.																		1						1

Table 10. Continued.

Order	Family	Species	Date of collection: May 26	May 28	June 9	June 15	June 22	July 7	July 9	July 15	July 18	July 20	July 31	August 8	August 12	August 19	August 21	August 24	August 27	August 29	Sept. 1	Sept. 4	Sept. 7	Sept. 12	Sept. 20	Tot.
	Anthophoridae																									
		Melissodes sp.														1										1
	Vespidae																									
		Odynerus sp.												1												1
	Sphecidae																									
		Crabro nr. vicinus Cress.		1																						1
		Notoglossa emarginata (Say)																1								1
	Halictidae																									
		Halictus sparsus Robt.												25	7	15	1	14								62
																								TOTAL		674

SUMMARY

1. In an extensive study of ironweed insects it was determined that at least 97 insect species, comprising nine orders and 41 families, were associated with ironweed directly by feeding on the plant, or indirectly as parasites, predators, or commensals of the phytophagous forms.

2. Besides 50 species which fed on ironweed more than 130 additional species were swept from the plant. The relationship of those insects to the plant was not determined but probably many of them such as the leafhoppers, hemipterons, and leaf beetles used ironweed for food. Others used the plant for shelter since it is well adapted for this purpose.

3. The feeding of these insects on ironweed was responsible for some degree of biological control of the plant. The roots, stems, leaves, petioles, and flower parts were all subject to attack. Those insects which damaged the flower parts, especially the seeds, and those which fed inside the stems and roots brought about the most effective injury to the plant from the economic viewpoint since this type of injury hindered the spread and propagation of the weed.

4. Following are the most important pests of ironweed, based on their abundance and effective damage to the plant.

Five species of Trypetidae, although heavily parasitized, destroyed approximately one-fourth of the seeds produced by the plants studied.

Three species of Cerambycidae burrowed in the stems. Population studies indicated that about 40 percent of the stems had at least one borer which reduced the stem to a hollow cylinder by the end of the growing season.

Sixty percent of the stems had cecidomyiidae galls, with an average of 11 galls per stem. An abundance of these insects resulted in deformity, splitting, and extreme brittleness of the stem.

Mordellistena pustulata larvae burrowed in over 95 percent of the stems, usually from two to five individuals in each stem. They were small and their injury was not great although they were more abundant than other borers.

A Pyralidid borer, Pyrausta oxydalis, was found in the crown or roots of about 20 percent of the plants inspected. The injury caused by this species may have been a limiting factor in the development of new shoots from roots in the spring.

5. Thirty-seven species of parasites, 11 of which were undescribed, were reared from ironweed insects and an additional 25 parasitic species swept from the plant. Four predators were found on the plant, two Chrysopidae, one Carabidae, and one Coccinellidae. Six species of ants were associated with two species of aphids which fed on ironweed, Vernonia interior.

ACKNOWLEDGMENTS

Appreciation is expressed to Mr. D. A. Wilbur, assistant professor of entomology, for suggesting this problem and for his helpful counsel during this investigation; to Mr. S. C. Schell and Mr. G. P. Engelhardt for information about ironweed insects; and to entomologists for determinations of ironweed insects as follows:

W. H. Anderson, Coleoptera; H. G. Barber, Hemiptera; H. S. Barber, Coleoptera; F. S. Blanton, Trypetidae; L. L. Buchanan, Curculionidae; J. C. Crawford, Hymenoptera; R. A. Cushman, Ichneumonidae; Kathleen C. Doering, Cercopidae; G. P. Engelhardt, Lepidoptera; E. P. Felt, Cecidomyiidae; W. S. Fisher, Coleoptera; R. F. Fritz, Acrididae; A. B. Gahan, Chalcidoidea; C. T. Greene, Diptera; D. G. Hall, Diptera; Carl Heinrich, Lepidoptera; A. B. Klots, Lepidoptera; K. V. Krombein, Hymenoptera; C. F. W. Muesebeck, Braconidae; R. H. Painter, Bombyliidae; M. R. Smith, Formicidae; R. C. Smith, Chrysopidae; Alan Stone, Chironomidae; F. M. Wadley, Aphididae; L. H. Weld, Cynipidae; D. A. Wilbur, Cicadellidae.

LITERATURE CITED

Aldous, A.E.
Management of Kansas permanent pastures. Kans. Agr. Expt. Sta. Bul. 272. 44p. 1935.

Blatchley, W. S.
Coleoptera known to occur in Indiana. Indianapolis. Nature Pub. Co. 1369p. 1910.

Blatchley, W. S. and Leng, C. W.
Rhynchophora or weevils of northeastern America. Indianapolis. Nature Pub. Co. 682p. 1916.

Beutenmuller, Wm.
Monograph of sesiidae of America north of Mexico. Amer. Mus. Nat. Hist. Mem. 1(6):284-285. 1901.

_____ New species of gall producing cecidimyiidae. Amer. Mus. Nat. Hist. Bul. 23:389. 1907.

Felt, E. P.
New species of gall midges. Jour. Econ. Ent. 4:552. 1911.

_____ Study of gall midges IV. N.W. State Mus. Bul. 186:135 1916.

_____ Key to American insect galls. N. Y. State Mus. Bul. 200:189. 1918.

Fernald, C. H.
Pterophoridae of North America. Mass. Agr. Col. Spec. Bul. 62p. 1898.

Gates, Frank C.
Flora of Kansas. Topeka. Kans. Agr. Expt. Sta. 254p. 1940.

Kelly, S. G.
Control of Noogoora and Bathurst burr by insects. Jour. Council Sci. Ind. Res. 4(3):161-172. 1931.

Loew, H.
Monograph of the diptera of North America. Smithsn. Misc. Collect. 1:99-101. 1862.

Metcalf, C. L. and Flint, W. P.
Destructive and useful insects, their habits and control. New York. McGraw-Hill. 910p. 1939.

Patch. E. M.
Food-plant catalog of aphids of the world. Maine Agr. Expt. Sta. Bul. 393. 430p. 1938.

Painter, R. H.
Biology of some dipterous gall-makers from Texas. Jour. Kans. Ent. Soc. 8(3):83-85. 1935.

Rydberg, P. A.
Flora of prairies and plains of central North America. New York. N.Y. Bot. Gard. 900p. 1932.

Sanborn, C. E.
Kansas aphididae with catalog of North American aphididae. Kans. Univ. Sci. Bul. 3(1):57-58. 1904.

Wilbur, D. A. and Fritz, R. F.
Use of shoebox emergence cages in the collection of insects inhabiting grasses. Jour. Econ. Ent. 32(4):571-573. 1939.