INSECTS ASSOCIATED WITH THE ROUGH PIGWEED, AMARANTHUS RETROFLEXUS L. (AMARANTHACEAE)

by

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INTRODUCTION

It is a well known fact that many of our most important insect pests utilize weeds as alternate host plants until their cultivated host plants are large enough to benefit the insect pests. Weeds also may be utilized, for overwintering quarters, for food, and for protection from various adverse ecological factors.

Each species of weed has its own insect population just as each economic plant has pests which render it unfit for human use. Unlike the economic plant, the important weed species have not been studied to any great extent to determine the insect species which utilize weeds as specific host plants; therefore, not much is known regarding species of insects attacking weeds.

The primary purpose of this problem was to determine the relationship of the insects, attacking Amaranthus retroflexus, to the cultivated crops. Another purpose was to establish the various relationships of insect pests to the rough pigweed; and also, record the various insects found upon the rough pigweed under different environmental conditions. Because numerous insects were collected during the course of securing data in the field, it became necessary to stress only the insects of major importance.

The problem was carried out in the vicinity of Manhattan, Kansas during the summer of 1949. The determination of most of the insects collected during that time was made by competent

authorities.

REVIEW OF LITERATURE

A review of the literature pertaining to the insects associated with the rough pigweed revealed a voluminous number of references, the majority of which included only casual citations regarding the inter-relationship of the rough pigweed with various species of insects.

Orthoptera

Zimmerman (1948) mentioned that a small cricket, Motioche vittaticollis (Stal.) fed upon the pollen of plants belonging to the genera Amaranthus, Euphorbia, Solanum, and Sonchus.

Homoptera

Forbes (1900) found that Agallia sanguinolenta Prov. fed upon a number of species of weeds especially pigweed and lambs quarter. He also noted that Aphis gossypii Glover, (Aphis cucumoris Forbes), the melon and cucumber aphis, fed on cucumber, purslane, popper grass, and pigweed. Forbes (1905) stated that the aphid Myzus achyrantes Monell was a pest of sugar beets and corn, and has been found in Missouri utilizing the common pigweed as a food plant. Bremner (1915) found the apple aphis,

Aphis sorbe, on Amaranthus retrofloxus, while Patch (1916) observed the potato aphid, Macrosiphum solanifolii Ashmead, feeding upon Amaranthus retrofloxus. Forbes (1920) stated that the corn root aphid, Aphis maidiradicis Forbes, has been repeatedly reported by his field assistants to have infested abundantly among other weeds, Amaranthus hybridus. Horsfall (1923) noted that the aphid, Aphis rumicis, fed on Amaranthus retrofloxus. Novinonko (1931), Russia, observed that Aphis fabae can transmit sugar beet mosaic disease to Amaranthus retroflexus from the sugar beet and back again to reinfest new sugar beets. Patch (1933-39) recorded the following aphids from Amaranthus retrofloxus: Aphis abbreviata Patch, A. evonymi Fab., A. gillettei Cowen, A. maidiradicis Forbes, A. middletonii Thomas, A. rumicis L., Macrosiphum gei Koch., M. solanifolii Ashm., Myzus pseudosolani Theobald, and Trifidaphis phaseoli Passerini. She also recorded the following from other members of the Amaranth family. Aphis achyranthi Theobald, A. fabae Scopoli, A. glycines Matsumura, A. gossypii Glover, A. helianthi Monell, A. medicaginis Koch, A. spiraecola Patch, Macrosiphum schranki Theobald, and Myzus persicae Sulzer.

Lepidoptera

Forbes (1900) reported the common garden webworm, Loxostege similalis Guen., widely distributed feeding largely on pigweed and purslane. Forbes (1900) also found the beet webworm,

Loxostege stricticalis Linn., to injure beets, but the usual food plant was believed to be lambs quarter, Chenopodium album. It has been collected on Amaranthus in Kansas, and Nebraska, and on tansy in Michigan. It was noticed that it did not web vegetation as much as the garden webworm. He also observed that the beet army-worm, Laphygma flavimaculata Harv., destroyed sugar beets but its principal food plants were observed to be pigweed, saltweed, wild sunflower, potatoes, and peas.

Forbes (1905) stated that the cotton-cutworm, Prodonia ornithogalli Guen., has a variety of food plants, among them the pigweed. He reported that the fall army-worm, Laphygma frugiperda Sn., fed upon purslane, lambsquarter, cocklebur, and pigweed. Mokrzecki (1913), Russia, found that the pyralid moth, Phlyctaenodes sticticalis L., fed upon A. retroflexus. Paddock (1913) observed that the sugar beet webworm, Loxostege sticticalis L., fed upon Amaranthus spp. Jones (1915), Porto Rico, found the beet-webworm, Pachyzancla bipunctalis, fed upon Amaranthus spp. Marcovitch (1917) noted that the larvae of Van essa cardui L., painted lady, rolled the leaf edges of the pigweed. Swenk (1918) observed the eggs of the sugar beet webworm are laid early in June on the pigweed, but did not indicate the species of pigweed.

Berger (1919) found the larval stage of the semitropical army-worm, Xylomyges ovidania Cram, feeding upon the fleshy leaves of Amaranthus. Huber and Meiswander (1924) recorded the pigweed, A. retroflexus, and ragweed as food plants of the

European cornborer, Pyrausta nubilalis (Hbn.). Barber (1924) recorded that the greatest winter mortality of the European cornborer in New England was in the stems of A. retroflexus and Echinochloa crusgali in the spring of 1922 and 1923. Kotlan (1929), Hungary, found one of the most common food plants of the European cornborer, Pyrausta nubilalis (Hbn.) to be A. retroflexus. Schopp (1931) found the smartweed borer Pyrausta ainslioi Heinrich infesting A. retroflexus and A. hybridus stems in Kansas. Sachtleben (1931), Hungary and Romania, collected larvae of Pyrausta nubilalis from A. retroflexus.

Isley and Baerg (1931) stated that the garden webworm, Loxostege similalis Gn., migrated to cotton when its host plant A. retroflexus, was cut down, while Sauer (1937), Brazil, found that Loxostege bifidalis migrated to cotton when species of Amaranthus were cut down. Judenko (1938) Poland, also reported, Pyrausta nubilalis (Hbn.), was associated with A. retroflexus. Jenkins (1945) found the beet webworm, Hymenia recurvalicus, damaged the silver beet in South West Australis. It has a wide range in North America, Hawaii, and Japan where the larvae feed upon Amaranthus spp. Smith, Bryson, Doan and Kelly (1943) found the garden webworm, Loxostege similalis Guen., infested the pigweed in Kansas.

Homiptera

Forbes (1900) found that negro bugs, Corimelaenidae,

Corinelaena pulicaria Germ., fed upon smartweed and pigweed besides a host of other plants. He stated that Osburn observed the eggs of the false chinch bug, Nysius angustatus Uhl., among the blossoms of A. retroflexus. He noted that the large eyed purslane bug, Geocoris bullatus Say, is abundant on sugar cane, but preferred purslane. It was also found on lambs quarter, pigweed, and smartweed.

Forbes (1900) reported Piesma cinera (Say) quite abundant on pigweed in the beetfields but scarcely any were seen on the beets; the species of pigweed was not given. It has been shown, that Piesma cinera will attack the beets if the pigweed becomes scarce. It lives on the smartweed, grasses, and a variety of trees among which the buckeye has been mentioned. It occasionally injured the blossoms of grapes in the spring, and the effect of its work upon the plant was evident upon badly infested pigweeds as indicated by the occurrence of many whitish dots which thickly mottled the surface. Adults are abundant from late May to July in central Illinois and again from October until time to hibernate. They overwinter under any convenient shelter, but are abundant under the loose bark of trees.

Mac Lennan (1919) found Lygus pratensis was a pest of A. retroflexus. Schubert (1927), Germany, observed the beet leaf bug, Piesma quadrata on Amaranthus spp. Holdaway (1947), in Hawaii, found species of Nysius mainly N. nigriscutellatus Usinger, and N. nemorivagus White, causing the leaves of the garden beet, Capsicum, Chinese spinach, and Amaranthus spp. to

wilt and die.

Coleoptera

Forbes (1900) found the blister beetle, Epicauta marginata Fabr., injurious to many economic crops and many wild plants, one of which was the pigweed. He also noted that the striped blister beetle, Epicauta vittata Fabr., fed on the common pigweed, and observed the three spotted flea beetle, Disonycha triangularis Say, feeding on the spiny pigweed, Amaranthus spp.

He stated that the pale striped flea beetle, Systena taeniata Melsh, was recorded upon a variety of weeds among which are mentioned ragweed, cocklebur and pigweed. This beetle also destroyed beets by the destruction of the leaf epidermis. Forbes (1900) found the yellow-backed flea, beetle, Disonycha xanthomelaena (Dalm.), (Disonycha collaris Fabr.) upon the beet especially in the larval form. The larvae fed on the underside of the leaf, and dropped to the ground when disturbed. The larvae gnawed the leaf surface causing discolored spots to appear on the upper side; but when the larva grew older they ate the entire leaf. This species was also found upon lambsquarter, chickweed, spinach, and pigweed. Forbes (1905) found that the carret beetle, Ligyrus gibbosus De G., utilized the pigweed as a foodplant.

Forbes (1905) found that the blister beetles, Epicauta vittata Fabr., and Epicauta marginata were so fond of Amaran-

thus spp. that they did not molest corn so long as there was pigweed growing in the cornfield. Sherman (1913) stated that he found the blister beetle, Epicauta marginata on Amaranthus spp. Graf (1914) noted that the sugar beet wireworm, Limonius californicus Mannh., larvae fed upon the roots of A. retroflexus. Vassiliov (1915) reported that in Russia, Lixus ascanii L. laid its eggs upon A. retroflexus from which the larvae migrated into the stalks of beet roots. Smyth (1917) reported from Puerto Rico that the white grub, Phytalus insularia, fed upon species of Amaranthus. Hayes (1917) found the larvae of Liguyrus gibbosus De G., feeding upon the roots of pigweed.

Vickery and Wilson (1919) observed the wingless "May beetle", Lachnosterna farcta, upon Amaranthus. Berger (1920) found larvae of Baris scolopacea Germ., in the stems of ragweed, Ambrosia artemisaefilis and pigweed, A. retroflexus. Forbes (1920) stated that the injuries of the "pale stripod flea beetle", Systena taeniata Say, are not confined merely to the corn plant; but, destroy weeds such as cocklebur, ragweed and pigweed.

Ramakrishna (1922) reported that in South India, the Amaranthus stem weevil, Lixus brachyrhinus Boh., was found in Amaranthus spp. Blunck and Gornitz (1923) found the beet silphid beetles, Blitophaga opaca1, and B. undata Mull., were very fond of Amaranthus. Van Zwaluwenburg (1926) reported from Mexico that the favorite food plant of Diabrotica finostralis Jac., was Amaranthus spp. Romanova (1928) reported from Russia that the larvae of Lixus subtilis Sturm fed in large numbers on

Amaranthus spp. Kuzmin (1935) reported that in Russia the beet weevil, Cleonus punctiventris Germ., attacked weeds so severely that many had to be resowed particularly A. retroflexus.

Diptera

Lintner (1882) noted that some (Anthomyiidae) principally Phorbia floccosa (Macq.) Mead., Chortophilia betarum n. sp., and Pegomyia vicina n. sp. mined in beet leaves so severely that the leaves could no longer be used as greens. These leaf miners were maggots which injured the leaves of A. retroflexus by mining. Forbes (1900) found that the leaves of Amaranthus spp. were mined by the beet leaf miners; these flies were Chortophila floccosa Macq., Chortophila betarum Lintn., and Pegomyia vicina Lintn. Cory (1916) reared Pegomyia hyoscyami Panz. from A. retroflexus.

Hawley (1922) found for many years the sugar-beet root-maggot, Tetanops aldrichi Hendel, a native ortalid fly, feeding on weeds such as Amaranthus spp. and he now has added the beet to the insects list of host plants. The maggot of this fly injured beets by feeding on the tap roots and is estimated to kill 50 to 75 per cent of the beet plants in various areas. The greatest damage occurred in sandy or loamy soil. Frost and Tothill (1928) stated that the anthomyid leaf miner, Pegomyia hyoscyami Panz. has mined the leaves of A. retroflexus.

Other leaf miners recorded are: Frost and Tothill (1928)

found Anthomyiidae, Pegomyia hyoscyami Panz, utilized Amaranthus retroflexus as a food plant. The eggs are laid in transverse rows on the under surface of the leaf. Upon hatching, which was from two to six days, the larvae made a small hole in the under surface of the leaf. All of the larvae hatched at the same time and worked in the same mine, but separated into different directions. The larvae upon reaching maturity pupated in two or three inches of the soil. These leaf miners overwintered as puparia. Needham, Frost, Tothill (1923) noted that an Agromyzidae, Scaptomyza adusta Loew, infested Amaranthus retroflexus. In New York, this species was the native cabbage leaf miner; and although, it attacks the Cruciferae; it mined in other leaves. The eggs are laid on the leaf surface and the young maggots ate their way into the interior of the leaf. As many as 23 were found in one leaf in which a small irregular blotch was found on the upper surface of the leaf. The adults apparently, hibernated in the adult stage.

Linter (1882) described the method of the general leaf miner feeding. The anterior end of the larvae is extended when feeding. Two black cutting mouthparts were extended acting like a pair of nippers. The larvae ate so rapidly that it suggest greediness and in excavating the parenchyma, the extensile anterior portion of the larvae permitted the jaws to sweep a curve of an entire semicircle.

Thysanoptera

Forbes (1911) observed that the onion thrips, Thrips tabaci Lind., breeds on almost any type of greenhouse vegetation. The onion thrips also breed on the seed head of such plants as A. retroflexus, wild sunflower, Helianthus annuus Linn., and fox tail grass, Setaria viridis L. Sakimura (1932) reported from Hawaii that he made a host list of the plants of Thrips tabaci but did not take the adults on A. retroflexus or A. hybridus. Zimmerman (1948) reported from Hawaii that Haplothrips gowdoyi (Franklin), the black flower thrips, were found on the flower heads of A. hybridus and A. viridis.

Zimmerman (1948) observed the host plants of the onion thrips, Thrips tabaci Lind., in Hawaii and has listed the following plants: A. retroflexus, A. viridis, boll popper, broad bean, broccoli, cabbage, carnation, carrot, cauliflower, celery, chard, eggplant, lettuce, nasturtium, spinach, onion (preferred host), pineapple, radish, rose, soybean, tobacco, and tomato. The onion thrip caused grave concern to pineapple growers, and truck garden crops by transmitting the yellow-spot virus, both of pineapple and tomato.

Miscellaneous

Forbes (1900) found that Hadronema militaris Uhl., infests beets and Amaranthus. Gates (1941) listed the following insects

associated with the pigweed: grasshoppers, garden webworm, Loxostege similalis Guen., pale striped flea beetle, Systena taeniata Melsh., spinach flea beetle, Disonycha xanthomelaena (Dalm.), carrot beetle, Ligyrus gibbosus De Geer, harlequin bug, Murgantia histrionica Hahn., and melon aphid, Aphis gossypii Glover. Fennah (1944) West Indies reported that the larvae of Psara bipunctalis F., fed on the leaves of beets, Amaranthus, and Celosia, portions of which were joined together forming a shelter. Plank (1946) stated that Hymenia recurvalis F., (fascialis Streel) damaged soy beans and also occurred on species of Amaranthus.

MATERIALS AND METHODS OF PROCEDURE

Amaranthus retroflexus L., Description and Discussion

Georgia (1914) described the rough pigweed, A. retroflexus, and also included much information about the plant. This plant was rarely absent from cultivated fields, and the seed can live for more than 30 years. The seed causes impurity of many commercial seeds (Georgia, 1914).

> Stem stout, tough, erect, green, rough, hairy, much branched occasionally attaining a height of ten feet, but usually one to six feet tall; springing from a long, fleshy, red taproot befringed with pink or white rootlets.
>
> Leaves long ovate or rhombic ovate, three to six inches in length, dull green, rough, hairy, with long petioles and prominent ribs and veins.

> Flowers are large, dense, terminal, and axillary panicles each subtended by three rigid, prickly bracts; they are very small, greenish, with five sepals and five stamens. Each flower produces but one oval, flattened, jet-black, and shining seed which readily shoots from its place when ripe.

Some of the other names supplied by Ada Georgia are the "red root pigweed" and "Chinaman's greens". This plant was introduced into the United States, is an annual and propagates by means of seeds. The blooming period is from July to September and the seed time is from August to November. This pigweed is distributed throughout North America except the North. It is a native of tropical America and inhabits waste places and cultivated ground.

Georgia also stated that A. blitoides Wats., A. graecizans L., and A. retroflexus are subjected to a white mold which attacks beets, and the roots may harbor on a beet feeding beetle, Systena taeniata Say in the larval and adult stage.

The pigweed has been observed in the field to vary in its manner of growth according to the environment in which it lives. When the weed grows in a dense growth of other plants it sends up a tall, erect, terminal stem bearing few, if any, lateral stems, and having a seed head longer than the normal seed head produced when crowding did not occur.

The growth of the plant, however, was quite opposite when found growing under less crowded and more favorable conditions. The pigweed under cultivated conditions grows to a height of six feet with a diameter of three to five feet, bearing many stout, lateral branches each producing a flowering head. The

leaves are ovate shaped and are usually light green in color.

The base of the stem measures two inches in diameter when growing under ideal conditions. The whole plant has been observed to remain green and succulent throughout the entire growing season, unless the plant falls a victim to one of its pests.

Methods of Procedure and Discussion

These weeds were studied at the field insectary, in the laboratory, and in the field at Manhattan, Kansas.

Field Insectary Studies. Most of the insect rearing were conducted in a screened entomological insectary. This building has an extension 15 x 18 feet with six 3 x 6' screened windows which were equipped with wooden shutters to be closed in the event of a severe storm. The environmental conditions were approximately the same as the out of doors so far as the temperature and humidity were concerned.

Immature stages of insects collected on pigweed in the field were brought into the insectary to be reared. In the field insectary, the immature insects were closely observed and, if possible, reared to the adult stage. Records were taken regarding the length of the life stages, habits of feeding, and the effect of these feeding habits upon the plants or plant portions. Leaves, stems roots, and seed heads, as well as entire plants showing injury were brought into the laboratory for further studies.

Laboratory Studies. The laboratory studies consisted of rearing immature forms of insects, pinning, mounting, or putting insects into preservative, parasite study, and studying feeding habits of stored grain insects upon pigweed seeds.

There were three approaches used in rearing insects; they consisted of a study of the insects of the leaf, stem, and the root. Rearing cages were made from cylindrical cardboard cartons.

Leaves or stems were placed into glass jars filled with about one inch of moist soil. When leaves were used, the leaves were placed upon the surface of the soil, and the collected insect, to be reared, was placed in the jar. The jar was then numbered and covered with a fine, meshed cloth, and tied to prevent the escape of the insect. The stem infesting insects were placed under observation in exactly the same manner as the leaves with the exception that stems were sometime hollowed out partially and the insects were placed inside.

The leaves were changed every other day, but stems when used were changed every week in order to supply fresh food.

Roots were collected from A. retroflexus whenever there were signs of infested plants and brought into the laboratory. Large glass jars were filled one-half full of soil and the infested root was placed into the soil. The soil covered the root partially in many instances, and in other instances the root was covered entirely. The jar was covered, numbered, and examined closely every week. When the root showed any signs of decompo-

sition, it was removed, and the larvae from it were placed into a fresh root.

Rearing cages were made from cardboard adhesive tape tubes, approximately 12 inches long and three inches in diameter, were used to study the insect pests of stems and seedhead. A small round hole was cut into the side of each tube, and into the hole was placed a small glass vial to permit the entrance of light to the insect upon emergence from the material placed into the carton. Into these cartons were placed the seedheads of the pigweed, and the stems, but no soil was placed into the carton. These cartons were numbered and collections were made when the insects entered the vial.

The insects were collected after they had emerged to adult stage from the leaves, stems, or roots of the pigweed inside the different containers. They were then killed in a cyanide jar, and pinned; each specimen pinned or placed in alcohol had a rearing record number, date of collection, and place collected. These insects were retained until they could be sent to specialists for identification.

Parasitized insects were collected whenever they were observed and brought into the laboratory to be reared to adult. The containers used were small glass vials which contained the parasitized insects. After the parasites had emerged they were collected and killed, and placed in alcohol or mounted on pins. The specimens also had a rearing number which bore the date of collection, host and habits.

Acting upon a suggestion from Professor D. A. Wilbur, an experiment was conducted in an attempt to rear stored grain insects upon the seed of A. retroflexus. The purpose of this experiment was to determine whether or not stored grain insects would be able to utilize pigweed seed as nourishment.

September 30, 1949, 50 plants were cut down and approximately two and one-half quarts of pigweed seeds were threshed from the seed heads. A pint of the seed was crushed in a hammer mill, making crushed seed to be utilized in the experiment.

Twenty-five two-ounce salve tins, having three one-half inch holes punched in the lids and the holes soldered with a fine grade of screen wire to prevent the escape of the insects, were used in the experiment. Five salve tins composed one set of tins, which were used for each species of grain pest.

Two of the five tins were filled about one-third full of whole seed. Two other tins were filled one-third full of crushed seed, while the final tin was filled one-third full of plain white flour. Each set of tins was composed of five tins for one species of grain pests. There were five species of grain pests utilized and the five sets of tins totaled 25.

The tins were placed in a rearing chamber at constant temperature (78° F.) and constant humidity (40° F.) for three months. From time to time the tins were examined to see whether the insects were still living.

The confused flour beetle, Tribolium confusum was used as experimental insects in Set No. 1. Into the following sets were

placed the following insects and mites: Set No. 2, the flat grain beetle, Laemophloeus minutus; Set No. 3, the rice weevil, Sitophilus oryzae; Set No. 4, the granary weevil, Sitophilus granarius and into the final, Set No. 5, a grain mite of the genus Eropoda.

Field Studies. The field studies consisted of observations of Amaranthus retrofloxus growing wild and in stations set aside for the study.

Plants growing wild at different places were visited at irregular intervals in an effort to observe insects which were not encountered upon the plants at five major stations. These wild Amaranthus plants were observed for insect injury, and various insects were collected.

Occasionally wild pigweeds were examined for the presence of insects when trips were made to St. George; Peabody; Kansas City, Kansas; and the Kansas State College Agronomy farm.

The stations used in the research were selected by June 16, 1949, and observations, and collections of insects continued at the stations until October 24, 1949. Laboratory work continued throughout the winter of 1949-1950.

The stations used in research contained one species of pigweed, Amaranthus retrofloxus. Each station was located in a different environmental condition in the vicinity of Manhattan, Kansas. Plants growing at some of the stations had to be replanted at first because the transplanted weeds were killed by the drought. A brief description of the location

and environment at each station are:

Station 1. The A. retroflexus plants were growing near a vegetable garden which included corn, onions, tomatoes, cucumbers, beets, beans, radishes, and turnips. East of the station about 10 feet was a barnyard, and between the barnyard and the A. retroflexus were various species of weeds. These weeds included: Chenopodium album, A. hybridus, Xanthium pennsylvanicum, Erigeron canadensis, and Solanum rostratum. The drainage was inadequate and the type of soil was a black silt loam. Twenty-six Amaranthus retroflexus plants were at this station.

Station 2. Amaranthus retroflexus plants were growing east of a garage and immediately west of a wheat field. Other species of weeds growing at this station near Amaranthus retroflexus included: A. hybridus, Chenopodium album, Solanum rostratum, and Erigeron canadensis. Drainage here was exceedingly good; the type of soil was black silt loam. The number of A. retroflexus plants growing in station 2 was 16.

Station 3. The experimental A. retroflexus plants were planted next to a trailer-house among a grass mixture which is unknown. Nearby was a very small garden which contained: lettuce, radishes, onions, and tomatoes. Few other weeds grew nearby; these weeds were A. hybridus, Chenopodium album, and Solanum rostratum. The drainage at this station was very good as the area was on a slope. The type of soil was also black silt loam. There were 18 plants at this station.

Station 4. Plants of A. retroflexus were growing on top

EXPLANATION OF PLATE I

Fig. 1. Amaranthus retroflexus growing in a pure stand at Insectary I, Kansas State College, Manhattan, Kansas.

Fig. 2. Amaranthus retroflexus growing in the natural environment at Insectary I, Kansas State College, Manhattan, Kansas.

PLATE I

Fig. 1.

Fig. 2.

of a slope immediately south of a group of barracks while nearby was a small garden containing tomatoes, carrots, and a few potato plants. Other species of weeds were abundant throughout most of the summer and included A. hybridus, Chenopodium album, Erigeron canadensis, Helianthus annuus, Cirsium altissimum, Ambrosia trifida and Solidago serotina. The drainage at this station was excellent. Twenty-six A. retroflexus plants were growing at this station. The type of soil was a black silt loam.

Station 5. Amaranthus retroflexus plants growing at this station were in a pure stand, no other weeds growing nearby except purslane, Portulaca oleracea. The reason for maintaining the pure stand was to determine whether the insects frequenting these plants were the same species of insects associated with the plants in the other stations. Corn, sorghum, and tomatoes grew near by but many feet away. The drainage at station 5 was inadequate and the type of soil was black loam. Fifty-three plants were growing at this location.

EXPERIMENTAL DATA

Insects Associated with the Leaves

The majority of the insects found upon the pigweed were associated with the leaves in some manner. Leaves were used as a source of food, protection from adverse weather conditions,

from insect enemies, as a place to deposit eggs, and as a supporting surface for insects on the plant.

The plant had an abundance of leaves under normal conditions which made considerable shade, and undoubtedly large numbers of insects were attracted to the shade as a means of escape from the hot sun. Since an abundance of insects was found upon the pigweed, it was difficult to distinguish between a visitor and a minor leaf feeder devouring leaves on few occasions; therefore, most of the insects discussed are those found regularly.

General Leaf Feeders. The general leaf feeder was one which had fed upon the leaf with no definite pattern.

The spinach flea beetle, Disonycha xanthomelaena (Dalm.) (Plate II, Fig. 5) is a small black beetle about $\frac{1}{8}$ inch long with an orange pronotum. The larvae were a little longer than the adult; whitish-grey in color, and somewhat wrinkled.

The spinach flea beetle was observed upon Amaranthus retroflexus and A. hybridus, as adults and larvae; however, the injury by the larvae exceeded that caused by the adults. On one occasion, eggs were found on the underside of the leaf, nearly all of the eggs hatched and the small larvae began feeding upon the under surface of the leaves. The larvae, were not abundant in the field. Their injury was characterized usually by the appearance of small circular holes on the under surface of the leaves extending through the entire leaves. There the tiny, wrinkled, greyish-white, larvae fed in the field, and dropped

EXPLANATION OF PLATE II

Fig. 3. Insect injury to the leaves of A. retroflexus caused by Plesma cinera (Say) at Manhattan, Kansas.

Fig. 4. Micrutalis calva Say, Membracidae, Homoptera.

Fig. 5. Circular holes made from the underside of A. retroflexus leaves by Disonycha xanthomelaena (Dalm.).

Fig. 6. Larva of Prodenia ornithogalli Guen., Noctuidae, showing curled leaf from which it was collected.

PLATE II

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

to the ground when disturbed.

The adults were abundant throughout the summer upon the leaves and flowering head of the pigweed; the first ones upon the pigweed were observed June 16, while the larvae were first observed June 22. The adults did not appear to damage the plants to any great extent. Metcalf and Flint (1939) stated the spinach flea beetle also attacked spinach, beets, chickweed, lamb's-quarters, and pigweed; furthermore, there appear to be two generations a year.

Chittenden (1922) noted that a close relative of the spinach flea beetle, the amaranth flea beetle, Disonycha glabrator Fab., caused severe injury to the leaves of the ornamental amaranths including A. caudatus, A. tricolor, A. cruentalis, A. celosia and A. plumosa. The roots of these plants contained larvae which fed in the root about an inch below the surface of the soil. The leaves of the plants were severely injured. This pest completely destroyed beds of ornamental plants in Washington, D. C. Garman (1891) noticed that both the adults and larvae of the amaranth flea beetle stripped the leaves from A. retroflexus in eastern Kentucky.

The adult of the spotted cucumber beetle was found abundant upon the rough pigweed and the smooth pigweed, A. hybridus. The adult was observed in the greatest numbers upon the flowering head, where it was believed to eat the pollen. No serious damage was found at any time as a result of the beetle and larvae of the southern corn rootworm. Webster (1913) reared

the southern corn rootworm upon Amaranthus sp., and mentioned that a parasitic fly, Colatoria diabrotica attacks this beetle. Forbes (1900) noted that the southern corn rootworm was a pest of sugar beets, unripe kernels of corn, petals of various flowers, and garden vegetables.

The grey blister beetle, Epicauta cinerea (Frost.), and the three-lined blister, Epicauta lemniscata Fab., were observed during July and August feeding upon the leaves of the pigweed. The grey blister beetle was a voracious feeder; moreover, two of these large blister beetles devoured a single leaf within a matter of three or four minutes. On the other hand, the three-lined blister beetles were not so abundant, nor were they as voracious in their feeding habits.

The salt marsh caterpillar, Estigmene acraea Drury (Plate III, Fig. 8) fed upon the plant as larvae. Since so much information has been written about this insect, it may be found described elsewhere. The larvae were variously colored from light yellow to a jet black. Under laboratory conditions the reddish-brown pupae were observed to be covered by the cast larval skin, and pupae were located under the leaves and sometimes in the loose soil.

The larvae were voracious leaf feeders and were observed abundantly in the field. No eggs were found; however, 13 newly hatched larvae were found on the underside of the leaf on the rough pigweed at Peabody, Kansas. The tiny larvae fed upon the epidermis of the leaf; when they became older they ate the

entire leaf. Larvae were first seen upon the pigweed June 6, 1949. During the entire summer 34 larvae were collected; but, more were seen and not collected because their characteristic form indicated the species present.

The length of time required to pass from the pupal stage to adult under laboratory conditions varied from 15 to 24 days. The salt marsh caterpillar was also observed feeding upon the smooth pigweed and Chenopodium album. Schwitzgebel and Wilbur (1942) found the salt marsh caterpillar fed upon Vernonia interior Small in considerable numbers; and recorded two generations a year.

The yellow-striped armyworm, Prodenia ornithogalli (Guen.) (Plate II, Fig. 6) was found very few times upon the plant. The adult was greyish-brown and somewhat mottled. The larvae are blackish in color with a well defined yellow stripe running longitudinally from the back of the head to end of the abdomen. Four were collected, but only one became adult in the laboratory.

Several species of grasshoppers were collected during the summer, but only one species was present to any extent. It was observed that the pigweeds growing adjacent to other weeds were damaged more severely than those not growing near other weeds. The grasshopper found in greatest numbers was Melanoplus femur rubrum (DeGeer.).

Other grasshoppers collected are Dissosteira carolina (Linn.), Melanoplus differentialis (Thomas), Melanoplus bivittatus Say, and Orphulella speciosa (Scudder). The first

three were reared in the laboratory on leaves from the rough pigweed.

Leaf Folder. One leaf folder was collected in abundant numbers during the summer. Pholisora catullus Fabr., belongs to family Hesperiidae and order Lepidoptera (Plate III, Fig. 7).

The adult was blackish brown with a wing span of one inch; the front wings bear numerous white dots, but the hind wings are plain. The larvae are 14 mm long, have a well defined black head, and a pea-green thorax and abdomen. Under field conditions the larvae attained a length of 24 mm with a width of 5 mm.

The leaf folder was one of the most common insects that utilized the rough pigweed leaves, and also occurred on the smooth pigweed. This insect was first observed June 28, but large numbers continued to feed throughout the summer reaching a peak in abundance during the last of July. The last skipper larvae was observed on Sept. 22, 1949, although no eggs were observed during the summer it is thought that the eggs are laid upon the leaf, and as the eggs hatch the young fed upon the upper epidermis of the leaf. One small larva was observed folding a leaf. The larva began at one side of the leaf took a small portion and fastened it down toward the center of the leaf by means of silken threads. This continued, bit by bit, until a complete fold was evident. The folding of the leaf took place within a 10-minute period. After the leaf had been folded the larva began feeding at one end of the fold.

In the fold, the larva was furnished protection, and seldom

EXPLANATION OF PLATE III

Fig. 7. The folded leaves of A. rotroflexus made by skipper larvae, Pholisora catullus Fabr., Hesperiidae.

Fig. 8. Injury to the leaf of A. rotroflexus made by the salt marsh caterpillar larva, Estigmene acraea (Drury).

PLATE III

Fig. 7.

Fig. 8.

ventured out with the exception of feeding. While the larva fed, about one-third of the body was extended out of the fold; consequently, within a few hours the open end of one fold assumed a ragged appearance. With the increase in size of the larvae new folds were made; moreover, the folds in the leaves made by the mature larvae at times extended to the mid-rib of the leaf.

Thirty-five skipper larvae were collected in the field and brought into the laboratory to be reared, but only 10 of that number lived to reach the adult stage. The larvae were observed to pupate within the folded leaf, both in the field and in the laboratory. The pupation period varied from 7 to 14 days. The number of generations per year may be two. Larvae collected after August 24 did not pupate but made a silken case in which the pre-pupa remained for overwintering.

The injury was caused by the larvae devouring the leaves. Even under a relative heavy infestation, the plant was not injured to any high degree. The highest number of larvae recorded from one plant was eight.

The skipper larvae found on the flowering head sometimes tied the leaf to the head; likewise, it tied one leaf to the other when they were close enough to be tied.

Leaf Miners. The larvae of the small dipterous leaf miner, Phytomyza minuta Frost (Plate V, Fig. 10) mined between the upper and lower epidermis of the leaf.

Some of the larvae measured 1.5 mm long and one-third mm

mm wide at the posterior end, while other larvae measured 2 mm long and 0.5 mm at the posterior end. The larvae were glassy white colored with the greenish black contents of the intestine showing through the cuticula.

The larvae usually made blotched mines (Plate IV, Fig. 9), but other times the mine was serpentine in form. In the mine, the feces of the leaf miner showed through the leaf quite distinctly. The leaf miner sometimes pupated in the mine and again was observed pupating in the soil in the laboratory. By holding a mined leaf up to the light, the maggots were seen quite distinctly in the leaf.

The damage to the leaf was slight, the portion mined split open as a result of the leaf tension while growing. Five larvae were found infesting one leaf which caused the whole leaf to die and drop to the ground.

Phytomyza minuta has also been collected from A. hybridus. The size of the mines varied from 8 to 11 mm long and 3 to 4 mm wide in the smooth and rough pigweed leaves. The leaf miners were first observed in August and the abundance reached its peak of population at the end of August when 171 leaves infested with leaf miners were collected from Insectary 1 on one day. The length of time for pupation varied from one to two weeks.

Another leaf miner collected was Pegomya ruficeps Stein (Plate V, Fig. 10). This also was a maggot infesting the leaves between the upper and lower epidermis.

These leaf miner larvae are 3.5 mm long; 1 mm wide at the

EXPLANATION OF PLATE IV

Fig. 9. *Amaranthus retroflexus* leaves mined by dipterous larvae, *Phytomyza minuta* Forst, Agromyzidae.

PLATE IV

Fig. 9.

EXPLANATION OF PLATE V

Fig. 10. Comparison between the larvae of the small leaf miner, Phytomyza minuta Forst, left, and the large leaf miner, Pegomya ruficeps Stein, center and right.

Fig. 11. A large leaf that mined within the leaves of A. retroflexus.

Left. Larva with the epidermis of the leaf removed, Pegomya ruficeps Stein, Muscidae.

Right. Larva of P. ruficeps Stein within leaf mine of A. retroflexus.

PLATE V

Fig. 10.

Fig. 11.

posterior end; and 1/3 mm wide at the anterior end. The larvae were whitish green in color and the dark contents of the alimentary canal showed clearly through the body. The last segment of the body has three protuberances. The maggot pupated in the soil, and the length of time for pupation was 12 days.

Pegomya ruficeps Stein makes a large mine as compared with the smaller leaf miner. The damage was slight; although, the leaf often curled up and died as a result of the feeding by the large leaf miner. The large leaf miner was found to be most abundant the last part of August and September upon plants of the genus Amaranthus growing wild. The leaves most heavily infested were those growing near to the ground. Rarely was more than one large leaf miner collected in a leaf. The largest number of larvae collected from any one station was 38.

Leaf Tiers. Leaf tiers may be differentiated from leaf folders in that the leaf tiers tie together the terminal portions of many leaves; whereas, the leaf folder merely folds over the leaf surface of one leaf.

Leaf tiers collected upon A. retroflexus belong to the order Lepidoptera, family Tortricidae. These insects have a common characteristic in that they tied the leaves of the pigweed.

Five different species of Tortricidae were found; they are as follows: Amolia pallorana (Robinson), Platynota flavonda Clemens, Platynota nigrocervina Wlshm., and Sparganothis sulfureana Clem.

The most abundant species of the family Tortricidae collected was found to be Platynota nigrocervina Wlshm. The other species collected were few in number and represented only a fraction of those reared. All of the species were reared in the laboratory.

They were first observed inside many leaves tied together by silken strands. They were first observed July 15. After the eggs hatched the larvae began feeding on the leaf epidermis; later, the larvae began tying two or three leaves together. As the larvae increased in size, many leaves were tied together, and the larvae fed upon the tissue of the leaf inside the leaves (Plate VII, Fig. 14).

This insect was last recorded upon the pigweed September 9. Among other plants infested are A. hybridus, ragweed, and lamb's-quarters. This species reached a peak in abundance the first part of August. Not more than six were found at any time together upon one plant.

The adults of P. nigrocervina were buff colored with a wing span of 15 mm and a length of 7 mm. The mesothoracic wings are marked with a black band across them, while the metathoracic wings are plain. The fore portion of the head capsule was projected into a pair of long tubial palpi.

The mature larvae varied from 18 to 20 mm in length, the head was light brown and connected to a light green thorax. The pupae are 7-8 mm long and are light to dark brown. The therax of the larvae bears many black spots and also distinct

EXPLANATION OF PLATE VI

Fig. 12. Flowering heads of Amaranthus retroflexus injured by larvae of Tortricidae, Lepidoptera.

Fig. 13. Larvae of Tortricidae, Lepidoptera.

Left. Immature larva.

Right. Mature larva.

PLATE VI

Fig. 12.

Fig. 13.

EXPLANATION OF PLATE VII

Fig. 14. Leaves tied by larvae of Tortricidae, Lepidoptera.

Left. Leaves of *Amaranthus retroflexus* tied by immature tortricd larvae.

Center. Leaves damaged by mature tortricid larvae.

Right. Advanced injury to tied leaves of *A. retroflexus* by mature larvae.

PLATE VII

Fig. 14.

sotoo.

The pupae of this species were found during the summer in the tied leaves. The larvae within the tied leaves hollowed out a passageway, or tunnel, and if disturbed sought shelter within the tunnel, backing in rapidly. The major damage caused by the leaf tier was a result of the larvae devouring of the leaves, making the plant assume a ragged appearance in the tied leaf area. This insect sometimes was found in leaves tied to the flowering head, when this occurred the larvae fed upon the peduncle, causing the flowering head to fall over and die (Plate VI, Fig. 12). The feeding upon the peduncle of the head cut down seed production. The length of the pupal period was approximately 10 days.

Sap Feeders. Empoasca solana De Long was one of the principal sap feeding insects of the leaves. It belongs to the family Cicadellidae, order Homoptera.

This insect was believed to be first seen during the first part of June; however, since the insect was determined to species by means of the genitalia the species occurring in June was not ascertained.

The insect was most abundant in August and September when by disturbing a plant a green mist or cloud of individuals of this species would fly into the air. One sweeping for 10 minutes at Insectary No. 1, 365 specimens were collected.

This insect occurred upon the plant until after the first frost. Many of the yellow spots and hopperburn damage was

believed to be a direct result of the feeding habits of this tiny green leafhopper. It was thought that the yellow spots are a direct result of saliva which was toxic to the plant leaves. Nymphs and adults were both collected from the plant during the summer.

De Long (1931) described Empoasca solana and said that it resembled Empoasca fabae in size, and appearance; however, Empoasca solana is bright green in color, without marking on the vertex or on the pronotum. It has distinct internal genitalia and this is the criteria used in the identification to species. He also stated the following description:

> Color; bright green, wash with yellow; vertex and pronotum strongly tinged with golden yellow; scutellum with a median white stripe and some yellow-white spots on the posterior half; elytra greenish subhyaline tinged with yellow.[1]

Hills (1944) in Phoenix, Arizona, noted that the production of sugar beet seed in outdoor cages was reduced by Empoasca solana, but the vitality of the seed was not reduced. Poos (1943) discovered that Empoasca solana breeds abundantly upon potato and Amaranthus retrofloxus at Arlington, Virginia. It has also been reared from the following plants Aster spp., Solanum nigrum L., Cestrum spp., Sechium edulo, Chenopodium ambrosioides L., Carica papya, and Phytolacca spp.

In Louisiana, it had been reported on cotton. It was found throughout the southern states extending from Florida to Cali-

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[1]Dwight M. De Long, "A revision of the American species of Empoasca known to occur north of Mexico," U. S. Dept. of Agr., Tech. Bul. 231, 50 p. 1931.

fornia, the northern most states being Missouri and Illinois. Empoasca solana has been taken from light traps in Kansas, Tennessee, and Virginia.

Poos also stated that the leafhopper causes leafhopper burn to potato, watermelon, castor bean, and produced a stippling or chlorotic spots on Amaranthus spp.

Empoasca solana was believed to be recorded for the first time in Kansas injuring plants. This species was found to infest A. hybridus, and was believed to occur upon the domestic morning-glory because specimens resembling Empoasca solana were observed during the summer.

Acoratagallia sanguinolenta (Prov.) was a small brown leafhopper and a sap feeder upon the leaves. It is 3 mm long when adult; this leafhopper was collected during July, August, and September. Forty-two leafhoppers were collected; however, this does not represent the true number present at any one time upon the pigweed. Gibson (1916) stated that the clover leafhopper, Aceratagallia (Agallia) sanguinolenta Prov., to decrease the yield of clover and alfalfa hay crops in this country. The injury to the crops is produced by the adult and small immature stages, piercing the epidermis and sucking out the sap contents.

The adult was light grey in color and had dark markings which gave a molted appearance. It was about 1/8 inch in length and about half as wide, Gibson collected 600 clover leafhoppers upon a single plant.

The early stages of injury are indicated by a yellowing of

the leaf tissue around the feeding punctures; later the leaf may curl and die. The leafhopper also produced injury to the flower buds and petals, and decreased seed production. Stems and leaves are injured by the female laying eggs into the tissue.

The principal plants attacked by Aceratagallia sanguinolenta are: the legumes such as beans, alfalfa, clover, cowpeas, and vetch. The clover leafhopper hibernated in the adult stage under leaves, trash, and clumps of grass.

Other leafhoppers collected from A. retroflexus were identified as: Neokolla hieroglyphica (Say), Nervellina seminuda Say, Neokolla hieroglyphica, unknown variety, Gyponana sp., Exitianus exitiosus (Uhler), Draeculacc phala mollipes (Say), Macrosteles sp., Paraphylepsius irroratus (Say), and Endria inimica (Say).

Neokolla hieroglyphica (Say) was reared and collected from June to August in abundant numbers. Nervellina seminuda Say was collected from May 29 to September, but was not collected abundantly during August and September.

The remainder of the leafhoppers were collected during the summer in numbers not exceeding eight specimens.

Webworms. Two species of webworm found throughout the summer, most commonly found was Loxostege similalis Guen., (Plate VIII, Fig. 15), and least commonly found was Pachyzancla bipunctalis (F.). They belong to the family Pyraustidae, order Lepidoptera.

EXPLANATION OF PLATE VIII

Fig. 15. Larvae of the garden webworm, Loxostege similalis Guen.

Fig. 16. Damage to Amaranthus retrofloxus by webbing and eating of the leaves by Loxostege similalis, Pyraustidae, Lepidoptera.

PLATE VIII

Fig. 15.

Fig. 16.

The larvae are about one inch long dark green with numerous black dots upon the segment of the trunk. The adults are light to dark buff colored and have a wingspan of three-fourths of an inch.

The larvae were found within a web which covered a small or even large portion of the plant. The larvae within the web had in many instances constructed a silken tube within which they entered when they were disturbed. The larvae were restricted not only on the leaves but were also found within a web (Plate VIII, Fig. 16) on the head of the plant.

The larvae were observed feeding on both A. retroflexus and A. hybridus during the summer. The larvae pupated within the silken web upon the plant; but under laboratory conditions they pupated in the soil. Six days were required for pupation in the laboratory. The webworms were first found June 24, 1949, and were last observed on Sept. 22, 1949. The larvae were extremely abundant during the entire summer.

Metcalf and Flint (1939) stated that the garden webworm was a general feeder and fed upon such plants as alfalfa, clover, beans, soybeans, cowpeas, sugar beets, peas, strawberries, wild sunflower, thistles, pigweed, ragweed, sweet clover, and a host of other plants.

Insects Associated with the Stem

Internal Feeders. Mordellistena spp., a mordellid was

noted to utilize the interior of the stem as food during its immature stages.

The color of the larvae varied from yellow to cream color, and were about 8 mm long. The adults were black, with a bronzy pubescence, and measured 3 mm long (Plate IX, Fig. 18).

The larvae were first observed inside the plants stems collected from the agronomy farm. These plants were split open and examined for evidence of stem boring insects on July 9, 1949. While cutting open many plants, several mordellids were found (Plate X, Fig. 19).

The larvae live in the stems of the plant (Plate IX, Fig. 18), where they made various longitudinal tunnels. The larvae eat the inner tissue cutting down the conduction of both food and water to the terminal portion of the plants. The usual injury produced by the mordellid larvae at first was a rosetting of the main stem which caused the leaves and lateral stems to become closely applied to the main stem. As the injury progresses the entire plant may die because at Insectary 1 six plants were lost as a result of mordellid injury.

These mordellids also caused injury to the head. This injury was also typical of mordellid feeding. As a result of the larvae feeding within the stem, the injury produced a malformation of the flowering head, or prevented the formation of seed heads (Plate IX, Fig. 17).

The most abundant number of larvae collected was 29 on July 29, while in two plants none was recorded. The larvae

EXPLANATION OF PLATE IX

Fig. 17. Damage to the flowering head of Amaranthus retrofloxus by larvae of Mordellistena sp. Mordellidae.

Left. Normal head.

Center. Longitudinal section through the stem showing the tunnels made by Mordellistena sp., and the moderate affect of the tunnels upon the head.

Right. Extreme damage by Mordellistena sp. showing no head formation because of their feeding.

Fig. 18. Larva, pupae, and adults of Mordellistena sp., Mordellidae, Coleoptera.

Left. Larva.

Center. Pupae.

Right. Adults.

PLATE IX

Fig. 17.

Fig. 18.

EXPLANATION OF PLATE X

Fig. 19. A longitudinal section of the stems of A. rotroflexus showing the larva and burrows of the larvae of Mordellistena sp., Mordellidae, Coleoptera.

Fig. 20. Rosetting of the terminal portions of Amaranthus rotroflexus due to the burrows made within the stem by larvae of Mordellistena sp., Coleoptera.

PLATE X

Fig. 19.

Fig. 20.

EXPLANATION OF PLATE XI

Fig. 21. Amaranthus retroflexus, the rough pigweed as it appears during the winter. The pigweed has many stems which provide protection for the larvae of Mordellistena sp., Coleoptera, at Manhattan, Kansas.

PLATE XI

Fig. 21.

pupated in the tunnels within the stems and small circular holes on the exterior of the stem indicated the emergence of the adult.

When the plant began to assume a rosetted appearance, the color of the leaves became lighter green, later they turned yellow and finally became brownish and died. Adults were first observed June 18, 1949. These mordellids probably emerged from the plants in which they had overwintered.

Studies on Mordolliatena overwintering in the stems of the plants (Table 2) revealed that a large number of mordellid larvae may be found in one plant. The highest number of individuals observed in one infested plant was 81, while the lowest number was one. It is believed that the amount of infestation was proportional to the size of the plant. The mordellid also attacked A. hybridus, the smooth pigweed.

Criddle (1922) reported from Manitoba, Canada, that the sunflower pith beetle larvae, Mordelliatena pustulata Melsh., were collected from the inside of stems of Amaranthus retrofloxus which had died prematurely. Later, the mordellid larvae were found hibernating in the stem of sunflowers. It was also noted that plants so injured had a stunted appearance and died outright.

Schwitzgebel and Wilbur (1942) observed that Mordelliatena pustulata also fed within the stems of the ironweed, Vernonia interior Small.

Professor D. A. Wilbur suggested that the stems of A. retrofloxus should be infested with the European cornborer, Pyrausta

Table 1. Number of Mordellidae (stems) and Curculionidae (root) found per plant, in Amaranthus retrofloxus and A. hybridus July 20, 1949 at Manhattan, Kansas.

Plant species	No. of Mordellids		No. of Curculionids	
	Larvae	Pupae	Larvae	Pupae
A. retroflexus			1	
" "	9		3	
" "	2		1	
" "	7		1	
" "	1		1	
" "	7		1	
" "	3		2	
" "	6		1	
" "	2		1	
" "	1		1	
" "	1		1	
" "	7	1		
" "	3			
" "	2		2	1
" "	1			
" "	2		3	
" "	3		2	
A. hybridus	9			
" "	27		1	
" "	15		2	
" "			3	
" "	29			2
" "	10			
" "	5		4	
Total	153	1	31	3

Table 2. Number of Mordellidae larvae overwintering in the stems of A. rotroflexus and also showing the mortality of adults and larvae in the same plant at Manhattan, Kansas.

Date examined	Living larvae	Mortality of the Mordellids	
		Larvae	Adults
Feb. 14, 1950	1	0	0
Feb. 14, 1950	1	0	0
Feb. 14, 1950	49	3	2
Feb. 20, 1950	81	2	2
Feb. 20, 1950	5	1	0
Feb. 20, 1950	4	1	0
Feb. 20, 1950	9	0	0
Feb. 20, 1950	40	2	2
Feb. 20, 1950	14	2	0
Feb. 20, 1950	34	3	4
March 5, 1950	47	1	3
March 5, 1950	25	1	3
March 5, 1950	26	1	0
March 5, 1950	47	0	0
Total	432	17	16

nubilalis (Hbn.) and the smartweed borer, Pyrausta einsliei Hein. In August, 24 stems were partially hollowed out and into each stem was placed one European cornborer, and into another 12 stems were placed one larvae each of the smartweed borer. From time to time those stems were observed and both the European cornborer, and smartweed borer appeared not to be satisfied with their new environment.

The borers often ate their way out of the stems and migrated to another stem in the same container where they entered other stems. In the winter March 26, 1950 the stems were again examined and the number of European cornborers was to be one. Two of the smartweed borers were alive.

Two European cornborers were found in the wild plants in the field during the course of the investigation. The entrance hole was about eight inches above the surface of the soil. The burrows in both instances had a length of about two and one-half inches. The larvae were identified by Professor D. A. Wilbur.

Papaipema nebris Guen. was another lepidopterous larvae found utilizing the rough pigweed. Two of these common stalkborers were found in Kansas City, Kansas in the same plant, Amaranthus retroflexus, the last of August. Nearby grew many ragweed, almost all of which were infested with the larvae of this species. A swelling or gall like growth was characteristic of the larvae's work. The larvae also had long tunnels in which they lived and fed upon the inner tissues. Two more common stalkborers were collected at the agronomy farm, and one

specimen from a wild plant at the Insectary 1.

Another insect was found inside the stem utilizing the rough pigweed as a home. The insect was identified as a queen ant, Cremastogaster lineolata (Say.). A total of six were collected, three during the summer and three during the winter. The queen in all instances was found within a hollowed out stem. There was no evidence of feeding upon the plant by the queens collected.

External Feeders. There were no important external stem feeders observed during the summer, that made use of the exterior alone. Insects were found from time to time that did utilize the tender portions of the stems as food. Empoasca solana, Micrutalis calva, and Piesma cinera were the most common insects observed feeding on the tender stems.

Deposition of Eggs in the Stem. Eggs were deposited in the stems by two species of insects late in the summer.

One species of tree cricket, Oecanthus nigricornis Walker, was found upon the plant during midsummer on until late fall.

The eggs of this species were deposited in the pith singularly, and close together. The eggs were about 1/8 of an inch long, yellow-orange in color, and contrasting in color against a white background of pith. The oviposition of the tree cricket caused no serious damage to the plant (Plate XII, Fig. 22), although tiny, almost invisible holes, were present through which the eggs were inserted.

One other species of tree cricket, Oecanthus angustipennis

EXPLANATION OF PLATE XII

Fig. 22. Stem of A. retroflexus showing oviposition by a tree cricket.

Left. Epidermis still on the stem.

Center. Epidermis removed to show hole in the stem.

Right. Eggs of tree cricket within pith.

Fig. 23. Stem of A. retroflexus showing oviposition by meadow grasshopper.

Left. Moderate destruction of epidermis by ovipositor.

Center. Same as left except blasting is greater.

Right. Eggs of meadow grasshopper within pith.

Fig. 22.

Fig. 23.

Fitch was collected during the summer.

The other species of insects which deposited eggs in the sten was a meadow grasshopper. Orchelimum nigripes Scudder laid its eggs in the pith the last of August and continued its egg laying through September.

The eggs (Plate XII, Fig. 23) were dark grey and about 1/4 of an inch long and were deposited one at a time in an irregular row.

When oviposition occurred the outer tissue of the stem was torn to shreds, but each shred remained attached to the main stem.

Oviposition of the tree cricket and meadow grasshopper were common throughout the summer upon many plants including A. hybridus and Chenopodium album.

Insects Associated with the Flowering Head

Utilization of the Seed for Food. No insects were found that utilized the mature seed of the rough pigweed as food. Several attempts were made to rear insects from mature seed. The ripened and unripened seed were placed within vials, as time passed, but no indication of insects feeding on the seed was observed.

The experiment conducted on the infestation of whole and crushed pigweed seed with Tribolium confusum, the confused flour beetle; Laemorpholeus minutus, the flat grain beetle; Sitophilus

oryza, the rice weevil; Sitophilus granuarius, the granary weevil; and, a mite belonging to the genus Tyroglyphus, revealed that those insects were not able to live on the pigweed seed. All of the insects remained alive in the flour.

Prior to grinding the pigweed seed in a hammer mill, an infestation of Indian meal moth eggs, Plodia interpunctella (Hubner) had taken place. Larvae of the species were discovered and were sifted out immediately from the crushed pigweed seed.

About a month later, webbed, crushed pigweed seed was observed about the edges of the circular tins. These larvae were left to feed, and attempts made to rear them to adult.

Three months after the actual infestation adults of the Indian meal moth began to emerge. March 13, 1950 larvae and adults were counted, the number of larvae was found to be 63, while the adults numbered 14.

Emergence of adults continued on into the end of the fourth month.

Microlepidoptera. Scythris trivinctella (Zeller), a brown webworm, (Plate XIII, Fig. 25) was found upon the head of the plants A. retroflexus and A. hybridus from August to September.

The brown larvae measured 12 mm long and 1 mm wide, with a whitish-yellow stripe extending mid-dorsally, from the prothorax to the posterior end of the abdomen. Two black spots were present upon the thorax.

The larvae produced a small web upon the head of the plant and also fed upon the leaves of the head.

The insects were not extremely abundant, but 24 were collected during the summer. Usually, not more than one larva was collected from one flowering head; although, on one occasion seven were collected from the same flowering head.

The pupae were always attached to a leaf by the posterior end of the abdomen. The pupae were encased within a thin silken cocoon. The total length of time for pupation to occur under laboratory conditions was found to be nine days.

Another species of microlepidoptera, Polychrosis, was collected from the head of the rough pigweed was a moth belonging to the family Olethreutidae. The name of the specimens were not known definitely; but they belong to the genus Polychrosis. Mr. J. F. Gates Clarke said that they may be Polychrosis cypripodiana Forbes., or P. n. sp.

About 12 specimens of the genus Polychrosis were collected during the summer on the pigweed. They occurred on the plant during July and August tying leaves in many instances. It was also noted that the larvae made an inch tunnel in the stem of the head upon two occasions. The larvae pupated upon the leaves or head, requiring seven days for the pupal stage.

The adults have a wingspan of $\frac{1}{2}$ inch, and are dull greyish black in color. They are about one-half as long as wide.

Thrips. Three species of thrips were collected during the summer and all species belonged to genus Frankliniella.

F. tritici (Fitch) and F. unicolor Morgan were collected June 30, in abundant numbers upon the seed head. F. maidis

Beach and F. unicolor were collected August 13, in considerable numbers.

October 22, 1949, two thrips were collected; they were the winter forms of Frankliniolla tritici (Fitch). The determinations were made by Stanly F. Bailey; he stated that the thrips of the genus Frankliniolla were the most difficult ones to determine to species. He also stated that the identifications were based on comparison with specimens from So. Carolina and Washington, D. C., and were determined by J. C. Crawford and J. G. Watts.

The number of thrips varied from 6 to 15 per head. Injury to the head was not severe although slight damage may have been present. The above mentioned thrips belong to the Family Thripidae, Order Thysanoptera. Watts (1936) recorded the flower thrips Frankliniella tritici (Fitch) as being destructive to cotton.

Among the numerous host plants attacked Amaranthus spp., has been mentioned. Plants belonging to the families Poaceae, grass family; Leguminosae, legumes; and Rosaceae, rose family, while Compositae, composites, and Brassicaceae, the mustard family are preferred.

Watts found the eggs to be creamy white, kidney-shaped, 0.25 mm long, and 0.1 mm in diameter. There were a 1 st instar, 2 nd instar, prepupa, pupa and adult stage. The adult female was approximately 1 mm in length and 1/3 mm wide. Color; brownish-yellow with orange in the region of the thorax. The

adult male measured 0.7 mm and is lighter in color than the female. The wings are quite frail which condition restricts the thrips to one host plant.

A generation may vary from 8 to 38 days depending upon the situation in which it is reared.

The eggs were placed in the leaf tissue by means of a saw like ovipositor which was forced into the leaf. Frankliniella tritici was found to be parthenogenetic. This thrip apparently does not hibernate in winter. Because in So. Carolina during the winter of 1933, second instar nymphs were found on oats at a temperature of 12 degrees F. This species of thrips has both a summer and winter host plant.

Van Poeteron (1922) reported from Holland that two new thrips have been observed feeding on Amaranthus spp. in hot-houses. These thrips were recorded as Taeniothrips orchidii Molt, and Scirtothrips longipennis Bagn. Bailey (1935) stated that the onion thrips, Thrips tabaci Lind, lay their eggs in the more tender plant tissue. The newly hatched thrips fed upon the same plant, and upon completion of the instar development dropped to the ground to complete the pupal stage.

He stated that when the onion thrips fed upon the plant, the head of the thrip exhibited a rooting motion; the unpaired mandibles scraped the tissue, and the maxillae further ruptured the surface lesion. This injury caused the sap to flow from the wound, and because a partial vacuum was created in the pharynx of the alimentary canal, the fluid meal flowed in to the mouth.

Horsfall and Fenton (1922) reported from Iowa that the onion thrips caused the onions to take on a yellowish-green color with a distinct yellow cast. This type of injury is known as blight. Close examination disclosed that the leaf epidermis had been punctured; the contents were sucked out, and caused the leaf to collapse, and the epidermis to be sunken.

Geometridae. Geometridae of an undetermined species, (Plate XIII, Fig. 24) was collected from the heads of Amaranthus retroflexus during late summer. They were first observed August 12, and continued to September 19, 1949. These insects were never actually abundant; however, at one station 11 were collected in one day, while in another station 31 were collected in a single day from the flowering heads.

The larvae infested the heads of the plants and apparently ate the flowers, and young tender leaves of the head. These larvae were very slow in movement and because they blended in so well with the environment they were very difficult to see upon the head.

The mature larvae varied in color from light-green to dark-brown. There was a yellow V-shaped band near the posterior end of the abdomen.

The adults were grey in color with black spots giving a mottled appearance to the adult. The wingspan was an inch while the length of the body was about one third of an inch. The time spent in the pupal stage was 21 days under laboratory conditions.

Tarnished Plant Bug. The tarnished plant bug, Lygus

EXPLANATION OF PLATE XIII

Fig. 24. Larva of an undetermined species of Geometridae found upon the flowering head of Amaranthus retroflexus.

Fig. 25. Larvae of Scythris trivinctella (Zeller), Scythrididae, found upon the flowering heads of Amaranthus retroflexus.

PLATE XIII

Fig. 24.

Fig. 25.

praetensis oblinoatus (Say), often referred to as "the sparrow of the insect world", belongs to the order Homiptora, family Miridae. Since much information has been written about this insect which is so common throughout many states, no description of the insect will be included.

It was found abundant upon the rough pigweed, A. retroflexus and A. hybridus. No nymphs were noted until after the pigweed produced a flowering head; after which as many as seven green nymphs could be found on one head.

The adults of this species also fed upon the leaves, by inserting their beaks into the epidermis and sucking out the sap contents. In addition, the adults were found upon the head of the plant, feeding upon the newly forming seeds.

The nymphs were found only upon the peduncle, leaves, and buds of the flowering head. The last date the adults were recorded upon the plants was after the second major frost Oct. 16, 1949.

Case Bearing Lepidoptera. Coleophora amaranthella Braun, (Plate XIV, Fig. 26) were found upon the pigweed late in the summer.

The yellowish-white larvae are 5.0 mm long and bear a case 7.0 mm in length. The prothorax bears 10 distinct brown spots, and extends over the head capsule similar to a shield. The mesothorax bears eight brown spots, while the metathorax bears six distinct brown spots. The head capsule was light brown in color.

EXPLANATION OF PLATE XIV

Fig. 26. Larvae of Coleophora amaranthella Braun (Coleophoridae) found upon the flowering head of Amaranthus retroflexus during late summer.

Top. Case bearing lepidoptera within the cases.

Bottom. Coleophorid larvae removed from their cases.

PLATE XIV

Fig. 26.

The larvae were first observed Sept. 26, 1949, upon the flowering head of the pigweed A. retroflexus. The larval cases are straw-colored and are difficult to distinguish from foreign matter upon the head of the plant; consequently, no larvae were reared through the winter, although they remained as larvae in rearing containers.

The larvae are exceedingly sluggish in their movements and gregarious in their feeding habits. When the head of the plants was disturbed, the larvae withdrew into their cases for protection. The cases remained attached to the flowering head.

The larvae usually fed upon the flowers of the head although, leaves and the tender peduncle constituted part of their diet. When feeding upon the peduncle, the terminal portion of the seed heads died; consequently, seed production was reduced. The average number found varied from 8 to 10, but in some instances 25-30 were collected from a single seed head. There is only one generation per year.

Piesma cinera (Say). Piesma cinera (Say) was one of the first insects found in the summer (Plate II, Fig. 3). It was found upon A. retroflexus and A. hybridus early as June 10, 1949. However, the numbers were few for only 10 frequented each plant at that time.

Before the production of the seed head only adults were seen upon the leaves of the plant. Numerous nymphs were discovered when the flowering head appeared; about 14 nymphs could be collected at a time upon the head. Collections of adults

were made during one day in June and from 50 plants an one station, a total of 368 adults were taken.

An uninjured plant was transplanted into a cage, and about 300 specimens were placed into the covered cage so they could not escape. After a week had elapsed, the plant was examined for injury. The leaves had a yellow speckled appearance indicating that injury was produced by Piesma cinera.

The insects were found abundantly upon the pigweed all summer, the number of individuals decreased upon dying plants. The last specimens of Piesma cinera were observed on Oct. 14.

Barber (1924) stated that Piesma cinera completely destroyed a plot of Amaranthus caudatus L. The leaves of the plant curled and fell to the ground, even though the buds of partly grown plants were destroyed. A. retroflexus and A. hybridus were also attacked, and the leaves were found curled.

He also stated that the eggs are deposited on the under surface of the leaves, where they lie on their side, parallel to the veins of the leaf. The eggs were usually deposited singly, but in some instances there were 20 or more eggs on a single leaf. The nymphs fed on the under surface of the leaves; therefore, they were furnished protection from various factors. New adults were found to be a light cream color, tinged with green; becoming darker.

The egg measured 0.72 mm long; 0.25 mm wide, color light yellow, cylindrical, the chorion bears 16 longitudinal ridges.

The first instar larva measured 0.74 mm long; 0.35 mm wide,

color was light yellow, eyes red. 2 nd instar 0.87 mm long, 0.53 mm wide, the color was light yellow with a faint tinge of green. 3 rd instar was 1.16 mm long; 0.66 mm wide wing pads nearly attaining 3 rd abdominal segment. 4 th instar was 1.75 mm long, 0.91 mm wide, color light yellow with a tinge of green. 5 th instar length was 2.5 mm and width was 1.1 mm.

Weiss and Lott (1924) found Piesma cinera on the horse chestnut in New Jersey. In Ohio, it was found overwintering under back of sycamore. Summers (1901) found the pigweed bug, Piesma cinera, on the leaves of grapes so abundant that it did considerable damage. It was also found on the flowering heads of Scirpus atrovoins, a rush, and A. retrofloxus was found to be heavily infested with all stages July 25.

They stated that the upper leaf surfaces were mottled and spotted with white; and some plants were almost entirely white from top to bottom due to the combined attacks of many hundreds of nymphs and adults. The injury appeared to be the most severe at the tips of the plants near the flowering head. Many of the very young tender leaves hung limp and white. Some of the flowering heads contained many eggs.

Micrutalis calva Say. The smallest treehopper in Kansas, Micrutalis calva Say, was found throughout the summer. The specimens were first collected June 10, and continued throughout the summer in abundant numbers.

This insect possesses sucking mouth parts which damage plants by sucking the sap content out of the different parts of

the plant. It was observed upon A. hybridus and A. retroflexus as both adult and nymph. As soon as the formation of the seed head began, nymphs began to appear. The insects reached a peak in abundance in July. The average plant infestation number was found to average 12. Many nymphs were collected from the heads of the plants at various times throughout the summer.

Micrutalis calva reached a peak in abundance during the middle of July and August, and continued in abundance throughout the rest of the summer. This species like Piesma cinera did not fly readily when the plant was disturbed. The membracid fed on the leaves, but there was little evidence of injury except a slight mottling of the leaves.

The adult (Plate II, Fig. 4) is about one-fourth inch long; widest at the prothorax, while the tip of the abdomen is the narrowest portion of the body. The pronotum is jet black and extends over the abdomen. The nymphs are lemon-colored during most of the nymphal period.

Other Insects Found Upon the Head. Epicauta pennsylvanica De G., a black blister beetle, was observed feeding upon the flowering heads of both Amaranthus retroflexus, and A. hybridus during the summer. This species was observed to occur in greater numbers upon A. hybridus than on A. retroflexus. On one occasion 47 blister beetles were observed upon one flowering head of A. hybridus making the entire head appear black. These black blister beetles were first observed in July and feeding continued until the middle of August. One yellow blister beetle,

Nemognatha immaculata Say, was also collected during July upon A. retroflexus.

The one-lined grasshopper, Schistocerca lineata Scudder, was collected from the heads of both A. retroflexus and A. hybridus during the entire summer. Like the black blister beetle, the one-lined grasshopper occurred in greater numbers upon the heads of A. hybridus.

Insects Associated with the Root

The most important insect found associated with the root was a snout beetle, Conotrchelus seniculus Lec., (Plate XV, Fig. 23). The larvae were first observed inside the root June 20, 1949 where they continued feeding until mid-September.

The larvae are creamy-white in color, possesses a brown head capsule, and are approximately one-half inch long. The larvae are semitransparent permitting the internal organs to show through the cuticula as a dull black mass.

The pupae are also creamy white, about the same length, and are found outside the root from one to three inches below the surface of the soil near the plant encased in a crude pupal cell made of soil. The adult is about one-fourth inch long, with a light band extending horizontally across the mid-dorsal portion of the elytra.

The adult was believed to lay its eggs, not found during the problem, upon the root. The larvae upon hatching begin to

feed upon the epidermis of the root, exposing small, longitudinal, strands of fibers. The grooves which they made by feeding ran in every direction. After some time had elapsed, the larvae ate their way into the interior of the root (Plate XV, Fig. 28). As many as five entrance holes were observed but two entrance holes was the usual number.

Some roots were examined which had no entrance holes, but after the roots were cut longitudinally, small white larvae were found eating away the interior of the root. That indicated that the adult may have eaten microscopic holes into the root, and the larvae worked inside the roots directly.

The taproot was the main region of damage; but when the lateral roots were present an infestation was also found in them. The large lateral roots were found damaged very few times.

The larvae made many winding tunnels inside the taproot (Plate XV, Fig. 27). The tunnels became larger with the growth of the larvae and the tunnels contained a yellow frass distributed throughout the length of the burrow. In the root, the larvae fed upon the tissue leaving vascular strands showing when the root was opened in severe cases of injury (Plate XV, Fig. 28). This condition usually resulted in the death of the plant (Plate XVI, Fig. 29). Secondary invasion of the root by some form of root rot organism usually followed making the root soft and spongy.

The larvae seldom ventured above the crown of the root, but often girdled the inner tissue just beneath the crown of

EXPLANATION OF PLATE XV

Fig. 27. Longitudinal sections of the roots of Amaranthus retrofloxus showing interior damage to the roots by a snout beetle, Conotracholus soniculus, Coleoptera.

Fig. 28. Roots of Amaranthus retroflexus showing the extremes of damage by Conotracholus soniculus.

Left. Slight damage to root by exterior feeding.

Center. Entrance holes into the root and exterior damage by feeding.

Right. Root of plant which died. Note extreme amount of damage by the snout beetle.

Fig. 27.

Fig. 28.

EXPLANATION OF PLATE XVI

Fig. 29. Two plants, *Amaranthus retroflexus*, which died by direct feeding upon the roots by a snout beetle, *Conotracholus seniculus*.

Left. A plant in the dying stage, but still living.

Right. A dead plant, note longitudinal section made up into the stem from the root to show how far feeding extends. Note the absence of lateral roots.

PLATE XVI

Fig. 29.

the root.

The girdled root was weakened to such an extent, that when the strong winds blew, both Amaranthus retroflexus and A. hybridus fell over due to the girdling by the snout beetle. Professor Harry Bryson remarked that while he was weeding his garden, the pigweed tops pulled up in his hands, and the roots remained in the ground. That girdling damage was found to be typical for this species of snout beetle.

At various stations a total of 21 pigweed plants were killed as a result of attacks by the snout beetles. The plants at first showed an off-colored light green appearance, later the leaves wilted, turned brown, and died. The number of larvae necessary to kill one plant was not determined, but at least six or more were required.

The adults were collected at the agronomy farm upon pigweeds growing along drainage ditches and the road side. Fifteen adults were collected upon the roots of these plants as the plants were dug.

Chittenden (1924) found C. seniculus fed upon a variety of cultivated amaranth plants growing in the vicinity of Washington, D. C. The roots showed upon examination that large numbers of larvae were working within the root. He stated that the amaranth plants in Washington, D. C. had an estimated damage of 90 per cent.

Another insect found upon the root of A. retroflexus was a termite (Isoptera) Rhinotermitidae. Immature reproductive forms

of the termite, genus Reticulitermes sp., were collected during July.

Other Insects Associated with the Pigweed

Parasites. Many parasites were found upon the insect pests of the plant during the summer. The following table (Table 3) shows the relationship of the parasites to their host.

Predators. Insect predators were found at all times upon all parts of the pigweed. No attempt will be made to give a description of each predator, but rather a short table (Table 5) listing the predators found upon the plant during the course of the summer.

Visitors and Shelter Seeking Insects. Various insect visitors comprising five orders, were collected during the summer upon the pigweed. The relationship that each insect had with the pigweed has not been definitely ascertained. Some of the insects were apparently seeking shelter, others were evidently resting, and some may have been feeding. At any rate, the following insects were collected upon the leaves, head, stem, and flying about the plant (Table 6).

A List of the Insects Believed to be Recorded for the First Time upon the Pigweed

The following insects were not found mentioned in the review of literature concerning insects associated with the pigweed,

Table 3. A list of the parasites collected and reared from their hosts during the summer 1949, at Manhattan, Kansas.

Order. Family. Species.	Period collected	Host
Diptera		
Larvaevoridae		
Carcolia reclinata (A.&W.)	Aug.	Estigmene acrea (Drury)
Porocera orocta (Coq.)	Aug.	Tortricidae
Hymenoptera		
Braconidae		
Apantelos pholisorae Riley	Aug.	Pholisora catullus Fabr.
Apantelos pholisorae Riley	Aug.	Tortricidae
Apantoles congregatus Say	Aug.	Tomato hornworm
Heterospilus sp.	March	Probably from Mordellistena
Meterorus autographae Mues.	June	
Microplitis n. sp.	July	Loxostege similalis (Guen.)
Chalcidae		
Brachymeria hammari Cwfd.	Aug.	Tortricidae
Eulophidae		
Chrysocharis parksi Cwfd.	Sept.	Phytomyza minuta (Frost)
Ichneumonidae		
Campolotis argonifrons (Cress)	Aug.	Loxostege similalis (Guen.)
Campolex validus (Cress)*	June	" " "
Mymaridae		
Gonatocorus sp.	July	
Pteromalidae		
Catolaccus aeneoviridis Gir.	Aug.	Pholisora catullus Fabr.
Scelionidae		
Telenomus dimmocki (Ash)	July	eggs unknown

*Insect was in poor condition, species not certain.

Table 4. Time required for insect parasites to undergo metamorphic change to adult.

Parasite	Date of collection	Parasite stage collected	Date adult	Host
Apanteles pholisorae Riley	8-20-49	Pupa	8-29-49	Pholisora catullus Fabr.
Apantoles pholisorae Riley	8-27-49	Pupa	9-3-49	Tortricidae
Brachymoria hammari Cwfd.	8-24-49	Larva	9-12-49	Tortricidae*
Campoletis argentifrons (Cress)	6-20-49	Larva	7-1-49	Loxostege similalis (Guen.)
Carcelia roclinata (A & W)	8-16-49	Larva	9-9-49	Estigmene acrea (Drury)
Catolaccus aenoviridis Gir.	8-22-49	Pupa	8-24-49	Pholisora catullus Fabr.
Microplitis n. sp.	7-15-49	Larva	7-25-49	Loxostege similalis (Guen.)
Phorocera orrecta Coq.	8-13-49	Pupa	8-20-49	Tortricidae

*Pupal stage of tortricid was parasitized by larvae of the parasite, B. hammari.

Table 5. Predators found upon Amaranthus retrofloxus during the summer 1949, at Manhattan, Kansas

Order. Family. Species.	Period collected	Number collected
Coleoptera		
Carabidae		
Lebia scapularis Dej.	Aug.	1
Lebia analis Dej.	Aug.	1
Cloridae		
Phyllobaenus pubescens Lec.*	June-Aug.	11
Phyllobaenus knausi	June-Aug.	6
Coccinellidae		
Anatis 15-punctata (Oliv)	June	1
Ceratomegilla fuscilabris (Muls)*	June-Aug.	14
Cycloneda munda (Say)*	June-July	10
Hippodamia convergens Guer.*	June-Aug.	25
Hippodamia gracialis (Fab.)	June	1
Hippodamia tredecim-punctata (L.)*	June-July	4
Melyridae		
Collops quadrimaculatus Fab.	June-Aug.	5
Hemiptera		
Anthocoridae		
Orius insidiosus (Say)*	July-Sept.	36
Reduviidae		
Sinea diadema Fab.*	June,July,Aug.	12
Zelus socius Uhl.	Aug.	1
Neuroptera		
Chrysopidae		
Chrysopa plorabunda Fitch.*	June-Aug.	3
Diptera		
Asilidae		
Atomosia sayii Johns*	Aug.	5
Atomosia puella (Wied.)*	June-Aug.	2
Dolichopodidae		
Condylostylus sipho (Say)*	June-Aug.	6
Diaphorus leucostomus Lw.*	July-Aug.	4
Hymenoptera		
Polistidae		
Polistes annularis (Linn.)*	July	1
Polistes variatus Crosson*	July	1

*More specimens found on the plant than were recorded.

Table 6. A list of visitor insects collected from Amaranthus retroflexus L., during the summer 1949, at Manhattan, Kansas.

Order. Family. Species.	Period collected	Number collected
Hemiptera		
Coreidae		
Anasa tristis (DoG.)	Aug.	6
Arhyssus lateralis (Say)	June	2
Aufeius impressicollis Stal.*	June-Aug.	18
Harmostes reflexulus (Say)	July	1
Liorhssus hyalinus (F.)	July	1
Cydnidae		
Sehirus cictutus (P.B.)	July-Aug.	11
Lygaeidae		
Blissus leucopterus (Say)*	June-July	9
Geocoris sp.	Aug.	3
Nysius ericae (Schill)	Aug.	4
Nysius sp.	June-July	3
Pachybrachius basalis (Dallas)	June	1
Miridae		
Adelphocoris rapidus (Say)	Aug.	1
Neurocolpus rubidus Knight	Aug.	1
Trigonotylus ruficornis (Geoffroy)	June	2
Nabidae		
Nabis alternatus Parshley	Aug.	2
Nabis roseopennis Reuter	July	4
Neididae		
Jalysus spinosus (Say)	July-Aug.	2
Pentatomidae		
Euschistus variolarius P. de B.	July-Aug.	7
Euschistus servus Say	June-Aug.	2
Solubea pugnax (Fabr.)	June	1
Podisus maculiventris Say	July-Aug.	6
Thyanta custator (Fabr.)	Sept.	1
Homoptera		
Aphididae		
Aphis maidis (Fitch)	July	1
Cercopidae		
Monecphora bicincta (Say)	July	1
Cicadellidae		
Coelidia olitoria (Say)	July	4
Dehecephalus flavicosta (Stal.)	June	1
Endria inimica (Say)	Aug.	1
Exitiansus exitiosus (Uhler)	Sept.	1
Graminella nigrifrons (Forbes)	Aug.	1
Cicadidae		
Tibicen sp.	Aug.	1

Table 6 (cont.).

Order. Family. Species.	Period collected	Number collected
Fulgoridae		
Acanolonia bivittata (Say)	July	1
Oliarus sp.	Aug.	1
Ormonsis pruinosa Say	July, Sept.	6
Scolops sucipes Say	June	1
Membracidae		
Corosa bulbalus Fabr.	July, Aug.	4
Coleoptera		
Buprestidae		
Acmaeoderma pulchella (Hbst.)	July	1
Cantharidae		
Chauliognathus marginatus Fabr.	July	1
Silis sp.	June-Aug.	3
Tryphorus latipennis Germ.*	June	3
Carabidae		
Lebia analis Dej.	Aug.	1
Lebia scapularis Dej.	Aug.	1
Cerambycidae		
Tetraopes tetrophthalmus (Forst.)	July	1
Chrysomelidae		
Ceratoma trifurcata (Forster)	July	
Chaetocnema confinis Cr.	June	1
" " denticulata (Ill.)	Aug.	5
" " sp.	July	2
Chrysochus auratus (Fab.)	July	2
Colaspis lata Schaffer	Unknown	1
Cryptocephalus leocomelas Suffr.	July	1
Diabrotica atriponnis (Say)		2
" " longicornis (Say)*	Aug.	3
" " vittata (Fab.)	June-July	6
Epitrix cucumeris (Harris)	June	1
" " sp.	July	1
Lema locontei Clark	July	1
Leptinotarsa decunlineata (Say)	June-Aug.	2
Longitarsus sp.	June	1
Myochrous sp.	June	1
Paria sp.	June	3
Phyllotreta sp.	June	1
Rhabdopterus sp.	July	1
Systena dimorpha Blake[3]	Aug.	9
Trirhabda sp.	June	1
Curculionidae		
Baris sp.	June	2
Baris sp.	Aug.	1
Centrinaspis ponicellus (Hbst.)	June	2
" " porscitus (Hbst.)	June	3

Table 6 (cont.).

Order. Family. Species.	Period collected	Number collected
Cosmobaris americana Csy.	June	5
Curculio sp.	Sept.	1
Dosmoris sp.	June, July	5
Lixus sp.	June	1
Rhodobaenus 13-punctatus (Ill.)	July	1
Rhynchitobaris cribrata (Lec.)	June	1
Stictobaris cribrata (Lec.)	June	11
Trichobaris sp.	June	1
Histeridae		
Pholistor sp.	Aug.	1
Lampyridae		
Lucidota sp.	June	7
Photinus pyralis L.	June	2
Phalacridae	June, Aug.	3
Scarabiidae		
Euphoria inda Linn.	Sept.	1
Diptora		
Chloropidae		
Meromyza americana Fitch	June	1
Larvaevoridae		
Genus and sp.	July	1
Lauxaniidae		
Camptoprosopolla sp.	June	6
Muscidae		
Hylemya sp.	June	2
Parogle cinerella (Fall)	June	1
Ortalidae		
Delphina picta Fabr.	July	4
Tetanops luridiponnis (Loew)*	June-Aug.	22
Otitidae		
Chaetopsis fulvifrons (Macq.)	June, Aug.	2
Sarcophagidae		
Sarcophaga hunteri Hough	June	1
" " latisetosa Park	Aug.	2
" " lherminieri (R. D.)	July	1
" " opifera Coq.	June-Aug.	2
" " rapax Walk.	July-Aug.	4
" " sp.	Aug.	3
" " stimulans Walk.	June-July	4
Tephritidae		
Neaspilota achilleae Johns	June	1
Therevidae		
Psilocephala haemorrhoidalis (Macq.)	June, Aug.	2
Trypotidae		
Tephritis aequalis (Loew.)	Aug.	2

Table 6 (concl.).

Order. Family. Species.	Period collected	Number collected
Hymenoptera		
Argidae		
Sterictiphora lineata (Roh.)*	June-Aug.	32
Formicidae		
Camponotus herculeanus pennsylvanicus (De G.)(Queen)	July	1
Crematogaster lineolata variety corasi (Fitch)		
Workers*	June	7
Winged males*	Aug.-Sept.	9
Queens[4]	Sept.,Feb.,March	6
Halictidae		
Lasioglossum (Chloralictus) sparsus (Robt.)*	Aug.	4

*More specimens were recorded than collected.

[3]Collected in Peabody, Kansas upon giant ragwood and A. retroflexus.

[4]Collected in the stems of A. retroflexus during summer winter.

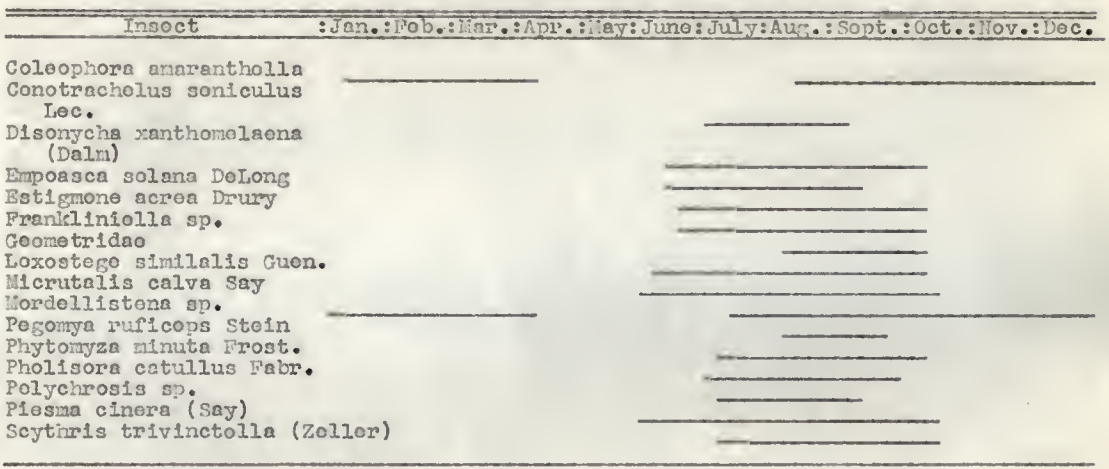
Table 7. A list of the insects believed to be recorded for the first time upon A. retrofloxus.

Scientific name	Scientific name
Amelia pallorana (Robinson)	Melanoplus femur rubrum (De G.)
Argyrotaenia velutinana (Wlk.)	Micrutalis calva Say
Dissosteira longipennis (Linn.)	Nookolla hieroglyphica (Say)
" " carolina (Linn.)	Norvellina seminuda Say
Draeculacephala mollipes (Say)	Oocanthus nigricornis Walker
Endria inimica (Say)	Orphulella apociosa (Scudder)
Epicauta pennsylvanica De G.	Pachyzancla bipunctalis (F.)
Estigmene acrea Drury	Papipema negria (Guen.)
Exitianus oxitiosus (Uhler)	Paraphepsius irrorstus (Say)
Frankiniella maidis Beach	Pogomya ruficops Stein
" " tritici (Fitch)	Pholisora catullus Fabr.
" " unicolor Morgan	Phytomyza minuta Forat.
Geometridae	Platynota flavonda Clemens
Gyponana sp.	Platynota nigrocorvina Wlahm.
Macrostoles sp.	Polychrosis sp.
Melanoplus differentialis Thomas	Scythris trivinctella (Zeller)
Melsnoplus bivittatus Say	Shistocerca lineata Scuddor
	Sparganothis angustiponnis Fitch
	" " sulfurosna Clem.

Table 8. Average time for major insects of the pigweed to undergo metamorphic changes. Manhattan, Kansas.

Species	Stage collected	Date collected	Date pupated	Date adult
Coleophora amaranthella Braun	Larvae	Sept.	Unknown	Unknown
Conotracholus seniculus Lec.	Larvae	7-19-49	7-22-49	8-1-49
Disonycha xanthomelaena (Dalm.)	Larvae	7-14-49	7-25-49	8-3-49
Estigmene acrea Drury	Larvae	6-24-49	7-13-49	7-28-49
Geometridae sp.	Larvae	8-27-49	9-1-49	9-22-49
Loxostege similalis Guen.	Larvae	8-14-49	8-22-49	9-9-49
Papaipoma nebris Guen.	Larvae	8-3-49	9-2-49	10-7-49
Pegomya ruficops Stein.	Larvae	8-26-49	9-2-49	9-14-49
Pholisora catullus Fabr.	Larvae	7-5-49	7-15-49	7-22-49
Phytomyza minuta Frost.	Larvae	8-13-49	8-27-49	9-3-49
Polychrosis sp.	Larvae	7-20-49	7-25-49	8-2-49
Scythris trivinctella (Zeller)	Larvae	8-12-49	8-15-49	8-24-49
Tortricidae sp.	Larvae	7-21-49	8-7-49	8-15-49

Table 9. Seasonal distribution of the insects of major importance found associated with the rough pigwood, *Amaranthus retroflexus* at Manhattan, Kansas, 1949.



A. retroflexus. Therefore, those recorded in Table 7 are believed to be recorded for the first time utilizing pigweed as a source of food.

CONCLUSIONS

1. The rough pigweed was found to be susceptible to the attacks of many insects; however, the plant only succumbed to the attacks of two species of insects, a mordellid, Mordellistena sp., and a snout beetle, Conotracholus soniculus.

2. The rough pigweed provided shelter or protection for a multitude of insects.

3. Amaranthus retroflexus served as a reservoir for many economic insect pests.

4. The pigweed provided food for many lepidopterous pests such as the hesperiid, garden webworm, tortricids, and the salt marsh caterpillar. When these lepidopterous insects were parasitized the pigweed held the pests, and when the parasites emerged some attacked economic insect pests.

5. Control of the pigweed by complete eradication would reduce the number of economic insect pests.

SUMMARY

Amaranthus retroflexus was studied to determine which insects were associated with it, and to determine whether any of

those insects were economic pests. The problem was conducted during the summer of 1949, and extended through the spring of 1950.

Five stations, each in a different environment, were used in the experiments, plus observations upon pigweed growing in areas other than the five stations. Field observations included the collecting of both adult and immature insects found upon the pigweed. Laboratory studies consisted of rearing immature insects in a field insectary which was similar to the outdoors so far as the humidity and temperature were concerned.

Amaranthus retroflexus was found to be indigenous to cultivated fields and waste land; moreover, the plant was found to be modified for every environment. The rough pigweed proved to be an attractive plant for large populations throughout the season. Many of these insects were found to be economic pests.

In the summer insects were found on every portion of the plant and no part of the plant was free from insect attack. In the winter the plant was a host to a mordellid, Mordellistena sp., as high as 81 larvae were found overwintering within one plant.

The pigweed was found to possess different populations of insects under various environmental conditions, and also the species of insects differed when the plant occurred under different environmental conditions.

A total of 219 different species of insects were found to be associated with Amaranthus retroflexus. Fifty of that number utilized some portion of the pigweed as food; 15 were

parasites reared from insect pests upon the pigweed; 19 species of predators were collected from the pigweed, and 135 species of insect visitors were collected.

The two most injurious insects to the pigweed were found to be a snout beetle and a mordellid. Mordellistena sp. fed within the stems occasionally killing the pigweed. Conotrachelus seniculus killed many pigweed plants by feeding upon the roots as larvae.

Common insects found throughout the summer are: the spinach flea beetle, Disonycha xanthomelaena (Dalm); blister beetles, Epicauta cinera (Frost), and Epicauta pennsylvanica DeG.; the salt marsh caterpillar, Estigmene acraea Drury; a leaf folder, Pholisora catullus Fabr.; leaf miners, Phytomyza minuta Frost, and Pegomya ruficeps Stein; leaf tier, Platynota nigrocervina Wlshm.; leaf hoppers, Empoasca solana DeLong, Acoratagallia sanguinolenata (Prov.), Mookolla hieroglyphica (Say), and Norvellina seminuda Say; garden webworm, Loxostege similalis Guen.; the tarnished plant bug, Lygus praetensis oblineatus (Say); Piesmidae, Piesma cinera (Say); Membracidae, Micrutalis calva Say; grasshoppers, Melanoplus femur rubrum, Shistocerca linoata Scudder, and Coleophora amaranthella Braun.

The most common parasite was a braconid, Apantelos pholisorae Riley, that parasitized the tortricids and hesperiids.

The ground pigweed seed indicated that some insects could utilize it as food. The Indian meal moth Plodia interpunctella (Hubner), is the only insect known at the present time that can

complete its life cycle from the egg through to adult upon crushed pigweed seed.

Thirty-six species of insects were believed to be recorded for the first time, and were not found recorded in the review of literature.

EXPLANATION OF PLATE XVII

An association of the insects most commonly observed upon the rough pigweed, Amaranthus retroflexus during the summer 1940, at Manhattan, Kansas.

Flowering head
- Coleophora amaranthella Braun
- Epicauta pennsylvanica DeGeer
- Frankliniella spp.
- Geometridae
- Lygus praetensis oblinostus (Say)
- Microrutalis calva Say
- Picsma cinera (Say)
- Polychrosis sp.
- Schistocerca lineata Scudder
- Scyturis trivinctella (Zeller)

Stem
- Mordellistena sp.
- Oecanthus nigricornis Walker
- Orcholimum nigripes Scudder

Leaf
- Aceratagallia sanguinolenta (Prov.)
- Diabrotica 12-punctata (Fab.)
- Disonycha xanthomelaena (Dalm)
- Haponaca solana Delong
- Epicauta cinerea (Forst)
- Estigmene acraea Drury
- Loxostege similalis Guen
- Melanoplus femur rubrum (DeGeer)
- Neokolla hieroglyphica (Say)
- Norvellina seminuda Say
- Pegomya ruficeps Stein
- Pholisora catullus Fabr.
- Phytomyza minuta Frost
- Platynota nigrocervina Walsm.

Root
- Conotracholus seniculus Lec.

PLATE XVII

FLOWERING HEAD

STEM

LEAF

ROOT

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