

INSECT ENEMIES OF THE CORN EARWORM

(HELIOTHIS OBSOLETA FABR.)

by

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## INTRODUCTION

One of the most destructive insect enemies of corn in the United States is the corn earworm (Heliothis obsoleta Fabr.) which annually does about \$40,000,000 damage to that crop. When it is considered that this insect is practically omnivorous and has over 100 plants upon which it may feed more of its economic importance is realized.

Because of the continued failure to discover a satisfactory control measure for the corn earworm, considerable

attention was devoted from May, 1930, until the winter season to the insect enemies which attack it.

This work was carried on at the field insectary in Manhattan, Kansas, in connection with Project 9 on "Corn Earworm and Other Insects Injurious to Corn". Some work was done along this line the preceding summer when the writer was interested in collecting all the Lepidoptera that attacked corn.

#### REVIEW OF LITERATURE

A survey of the literature yielded eighty-two different insect enemies of Heliothis obsoleta Fabr. that have been reported from different parts of the world. This list arranged by families and orders according to Comstock, is given in Table I. Information as to synonyms, stage of host attacked, locality from which recorded as parasitic, and literature references are given. Where two of the latter are cited the second is for taxonomic purposes only. For the taxonomy of the remaining the well known publications by Della Torre (1892-8), Van Duzee (1917), Leng (1920), Britton (1916, 1923), Blatchley (1910), and Leonard (1928) were used. Where no definite statement was made in the literature it was assumed that the insect was a larval parasite.

Table I. Insect Enemies of the Corn Earworm

Name	Synonyms	Stage of : Host : Attacked :	Locality : Reported : From :	Literature
NEUROPTERA				
Chrysopidae				
* <u>Chrysopa oculata</u> Say	: <u>C. chlorophana</u> Bks.	: Egg and	: Commonly	: Garman and Jewett (1914)
	: <u>C. albicornis</u> Fitch	: larvae	: reported	
** <u>Chrysopa plorabunda</u> Fitch		: Egg and		
		: larvae		
HEMIPTERA				
Miridae				
<u>Cyrtopeltis varians</u> Dist.		: Egg and	: Florida :	: Rosewall and Smith (1930)
		: larvae	: and Texas :	
Anthocoridae				
* <u>Orius insidiosus</u> (Say)	: <u>Triphleps insidiosus</u> Fieber	: Egg and	: Commonly	: Phillips and King (1923)
	: <u>Reduvius insidiosus</u> Say	: larvae	: reported	: Marshall (1930)
<u>Triphleps australis</u> China		: Egg	: Australia :	: China (1926)
Nabidae				
* <u>Nabis ferus</u> L.	: <u>Coriscus ferus</u> Stal.	: Larvae	: Commonly	: Garman and Jewett (1914)
			: reported	
Lygaeidae				
<u>Geocoris punctipes</u> Say	: <u>G. luniger</u> Fieber	: Young-	: Southern	: Mally (1893)
	: <u>G. pictipes</u> Montandon	: larvae	: States	
Coreidae				
<u>Acanthocephala femorata</u> Fabr.	: <u>A. nasulus</u> Say	: Larvae	: Southern	: Riley (1885)
	: <u>A. bispinus</u> Westw.		: States	
	: <u>A. obscurus</u> Westw.			
Pentatomidae				
<u>Glypsus conspicuus</u> Westw.		: Larvae	: Africa	: Haines (1926)
<u>Podisus spinosus</u> Dalt.		: Larvae	: Commonly	: Riley (1885)
			: reported	
COLEOPTERA				
Carabidae				
<u>Calosoma sycophanta</u> L.		: Larvae	: Africa	: Berlese (1916)
Cantharidae				
* <u>Chauliognathus marginatus</u> Fabr.	: <u>C. hentzi</u> Lec.	: Larvae	: Commonly	: Phillips and King (1923)
			: reported	
<u>Chauliognathus pennsylvanicus</u> DeG.	: <u>C. americanus</u> Forst.	: Larvae	: Commonly	: Phillips and King (1923)
	: <u>C. bimaculatus</u> Fabr.		: reported	
Coccinillidae				
* <u>Ceratomegilla fuscilabris</u> Muls.	: <u>Megilla maculata</u> auct. not DeG.	: Larvae	: Commonly	: Phillips and King (1923)
	: <u>Megilla strenua</u> Casy	: and Egg	: reported	
* <u>Hippodamia convergens</u> Guer.		: Egg and	: Commonly	
		: larvae	: reported	: Phillips and King (1923)
DIPTERA				
Asilidae				
<u>Deromyia angustipennis</u> (Loew.)	: <u>Diognites angustipennis</u> Loew.	: Adult	: Texas	: Quaintance and Brues (1905)
<u>Erax interruptus</u> Macq.	: <u>E. maculatus</u> Macq.	: Adult	: Southern	: Mally (1893)
			: States	: Hine (1919)
	: <u>E. lateralis</u> Macq.			
	: <u>E. ambiguus</u> Macq.			
	: <u>E. villosus</u> Bellardi			
Phoridae				
<u>Aphiochaeta nigriceps</u> Loew.	: <u>Phora aletiae</u> Comstock	: Larvae	: Southern	: Mally (1893); Brues (1906)
			: States	
Sarcophagidae				
<u>Sarcophaga latisterna</u> Park		: Larvae	: Virginia	: Phillips and King (1923)
Tachinidae				
<u>Achaetonema aletiae</u> Riley	: <u>Tachina fraterna</u> Comstock	: Larvae	: Missis-	: Allen (1926); Webber (1930)
	: <u>T. aletiae</u> Riley		: sippi	
	: <u>Frontina aletiae</u> Riley			
<u>Archytas piliventris</u> V.d.W.		: Larvae	: Southern	: Quaintance and Brues (1905)
			: States	
<u>Euphorocera claripennis</u> Macq.		: Larvae	: Southern	: Quaintance and Brues (1905)
			: States	
<u>Exorista ceratomiae</u> Coq.		: Larvae	: Southern	: Quaintance and Brues (1905)
			: States	
<u>Exorista pyste</u> Walker		: Larvae	: Virgin	: Wilson (1923)
			: Islands	
<u>Achaetoneura archippivora</u> (Will.)	: <u>Tachina archippivora</u> Riley	: Pupa	: Hawaii	: Fullaway (1914); Webber (1930)
	: <u>Masicera archippivora</u> Will.			
	: <u>Meigenia websteri</u> Towns.			
	: <u>Phorocera promiscus</u> Towns.			
	: <u>Ypophyaemia malacosomae</u> Towns.			
	: <u>Parafrontina apicalis</u> B. & B.			
	: <u>Masicera panciseta</u> (Coq.)			
	: <u>Masiceropsis panciseta</u> Towns.			

Table I. Insect Enemies of the Corn Earworm (Cont'd)

Name	Synonyms	Stage of Host Attacked	Locality Reported From	Literature
Tachinidae (Cont'd)				
<i>Lydella armigera</i> (Coq.)	: <i>Tachina (Masicera) armigera</i> Coq.	Larvae	Commonly reported	Quaintance and Brues (1905)
	: <i>Frontina armigera</i> Coq.			Webber (1930)
<i>Achaetoneura frenchii</i> (Will.)	: <i>Achaetoneura hesperus</i> B. & B.	Larvae	Commonly reported	Quaintance and Brues (1905)
	: <i>Phorocera promiscua</i> Towns.			Webber (1930)
	: <i>Mugenia websteri</i> Towns.			
	: <i>Tachina anonyma</i> Riley			
	: <i>Masicera frenchii</i> Will.			
	: <i>Masicera datanarum</i> Towns.			
	: <i>Frontina malacosomae</i> Curran			
	: <i>Frontina sordida</i> Curran			
	: <i>Frontina frenchii</i> Will.			
<i>Gonia capitata</i> DeG.		Larvae	Southern States	Quaintance and Brues (1905)
<i>Linnaemyia longirostris</i> Macq.		Larvae	So. Africa	Entomological Notes (1928)
<i>Paratachina ingens</i> B. & B.		Larvae	So. Africa	Entomological Notes (1928)
<i>Phorocera blepharida</i> B. & B.		Larvae	So. Africa	Entomological Notes (1928)
<i>Spallanzania bucephala</i> Meig.	: <i>Cnephalia bucephala</i> Meig.	Larvae	Russia	Rodinov (1927)
<i>Sturmia laxa</i> Curran		Larvae	Africa	Curran (1927)
<i>Tachina rustica</i> Fall.		Larvae	Russia	Rodinov (1927)
<i>Winthemia quadripustulata</i> Fabr.		Larvae	Commonly	Allen (1925)
		and pupae		reported
<i>Zenillia illita</i> Villen		Larvae	Africa	Curran (1927)
Muscidae				
<i>Muscina stabulans</i> (Fall.)	: <i>M. cinerascens</i> Wiedemann	Pupae	Russia	Rodinov (1927)
	: <i>Cyrtoneura stabulans</i> (Riley)			
HYMENOPTERA				
Braconidae				
<i>Apanteles</i> sp.		Larvae	Fiji	Simmonds (1926)
<i>Apanteles flavipes</i> Cam.	: <i>A. nonagriae</i> Alliff	Larvae	England	Wilkinson (1929)
<i>Apanteles marginiventris</i> Cress.	: <i>A. grenadensis</i> Ashm.	Larvae	Commonly	Vickery (1929);
	: <i>A. (Protapanteles) hardedi</i> Vier.			reported; Muesebeck (1920)
	: <i>A. laphygmae</i> Ashm.			
	: <i>A. militaris</i> Walsh			
<i>Apanteles papilionis</i> Vier.	: <i>A. angamemnonis</i> Wlkn.	Larvae	England	Wilkinson (1929)
<i>Apanteles ruficornis</i> Hal.	: <i>A. antipoda</i> Ashm.	Larvae	England	Wilkinson (1929)
<i>Bracon Kitcheneri</i> D. & G.		Larvae	India	Husain (1924)
<i>Chelonus</i> sp.		Larvae	India	Chopia (1928)
<i>Chelonus texanus</i> Cress.		Larvae	Texas	Luginbill (1928)
<i>Habrobracon plotnikovii</i> Bogoljubov		Larvae	Turkestan	Bogoljubov (1914)
<i>Habrobracon simonovi</i> Taschkent		Larvae	Turkestan	Kokujev (1914)
<i>Meteorus laphygmae</i> Vier.		Larvae	Texas	Luginbill (1928)
<i>Microbracon simonovi</i> Kok.		Larvae	Russia	Rodionov (1927)
<i>Microplitis croceipes</i> (Cress.)	: <i>Microgaster croceipes</i> Cress.	Larvae	Southern States	Quaintance and Brues (1905)
	: <i>Microplites nigripennis</i> Ashm.			
* <i>Microplitis</i> sp., near <i>melianae</i> Vier.		Larvae		
Ichneumonidae				
<i>Amblyteles crespatorius</i> L.		Larvae	Russia	Rodinov (1927)
<i>Atractodes</i> sp.		Larvae	India	Chopia (1928)
<i>Barylypa humeralis</i> Brauna		Larvae	Russia	Rodinov (1927)
<i>Henicospilus concolor</i> Cress.		Larvae	Virgin Islands	Wilson (1923)
<i>Paniscus geminatus</i> Say		Larvae	Virginia	Phillips and King (1923)
<i>Paniscus geminatus</i> var. <i>sayi</i> Cush.		Larvae	Mississippi	Vance (1927)
<i>Paniscus spinipes</i> Cush.		Larvae	Mississippi	Vance (1927)
* <i>Sagaritis provancheri</i> Dal.Torre	: <i>S. dubitatis</i> Cress.	Larvae	Commonly	Vickery (1929)
				reported
Proctotrupoidae				
<i>Neotelenomus</i> sp.		Egg	Australia	Veitch (1927)
* <i>Telenomus heliothidis</i> Ashm.		Egg	Commonly	Quaintance and Brues (1905)
				reported
Chalcidoidae				
<i>Chalcis annulata</i> Fabr.		Larvae	Virgin Islands	Wilson (1923)
<i>Chalcis ovata</i> Say		Larvae	Southern States	Mally (1893)
<i>Chalcis robusta</i> Cress.		Larvae	Virgin Islands	Wilson (1923)
<i>Euplectrus comstocki</i> How.		Larvae	Southern States	Luginbill (1928)
* <i>Euplectrus platyhyphenae</i> How.		Larvae	Southern States	Luginbill (1928)
<i>Spilochalcis femorata</i> Fabr.		Larvae	Virgin Islands	Wilson (1923)
<i>Spilochalcis vittata</i>		Larvae	Virgin Islands	Wilson (1923)
<i>Trichogramma australicum</i> Gir.		Egg	Australia	Veitch (1927)
* <i>Trichogramma minutum</i> Riley		Egg	Commonly	Phillips and King (1923)
				reported
<i>Trichogramma pretiosa</i> Riley		Egg	Commonly	Quaintance and Brues (1905)
				reported
<i>Trichogramma rarum</i> Gir.		Egg	Australia	Veitch (1927)
Formicidae				
<i>Dorymyrmex pyramicus</i> Roger		Larvae	Southern States	Mally (1893)
<i>Lasius niger americanus</i> Emery		Larvae	Illinois	Flint (1914)
<i>Monomorium carbonarium</i> Smith		Egg and larvae	Southern States	Quaintance and Brues (1905)
<i>Solenopsis geminata</i> Fabr.		Egg and larvae	Commonly	Quaintance and Brues (1905)
				reported
<i>Solenopsis molesta</i> Say		Egg and larvae	Commonly	McColloch and Hayes (1916)
				reported
<i>Solenopsis texana</i> Emery		Larvae	Texas	Quaintance and Brues (1905)
Vespidae				
<i>Eumenes bolli</i> Cress		Larvae	Texas	Quaintance and Brues (1905)
<i>Eumenes maxillosus</i> DeG.		Larvae	So. Africa	Munro (1926)
<i>Polistes annularis</i> Linn.		Larvae	Commonly	Quaintance and Brues (1905)
				reported
<i>Polistes rubiginosus</i> Lepel.		Larvae	Commonly	Quaintance and Brues (1905)
				reported
<i>Polistes schach</i> Fabr.		Larvae	Australia	Currie (1928)
<i>Polistes texanus</i> Cress.		Larvae	Texas	Quaintance and Brues (1905)

\*Collected on corn or reared at Manhattan in connection with this study.

\*Reported for first time as attacking corn earworm.

\*See Aldrich "Catalogue of North America Diptera", page 471, for 14 synonyms reported in Annales Soc. Ent. France.

In the literature five orders are represented as containing enemies of the corn earworm, including 46 species of Hymenoptera, 22 of Diptera, 8 of Hemiptera, 5 of Coleoptera, and 1 of Neuroptera. To this list one species of Neuroptera and one of Hymenoptera can be added from the work at Manhattan during 1930.

Under the heading "Locality Reported From" the entry is made "Commonly Reported", if two or more references are at hand reporting that insect as parasitic. Otherwise, the locality from which it was reported is given.

A number of the insect enemies are reported from the "Southern States". Practically all of these were reared from H. obsoleta larvae that were feeding on cotton. In fact, most of the parasites are reported from southern parts or southern countries. This either means that more work was done there or that the conditions are better for the parasites. The latter is more likely the case.

South America and Central America are supposed to be the original home of the corn plant. If corn is the primary host of H. obsoleta, as is generally thought, we would expect to find the more specialized parasites in that area. However, the literature contained no references to parasites from those localities. This is undoubtedly due to lack of information which should be supplied before our knowledge of the insect enemies of the corn earworm is

complete.

Of the nine American Tachinids reported there are only two that may be specialized parasites on H. obsoleta. The rest are parasitic on a large number of insects.

The same applies to the Hymenoptera to a certain extent. Trichogramma minutum and Sagaritis provancheri are common examples of those that have many hosts.

While H. obsoleta has a large number of insect enemies the majority of them are only of passing interest because of this lack of specialization. There are several however that do much good.

Jarvis (1924) (Queensland, Agric. Jl.) in speaking of the corn earworm states, "Fortunately, this pest is kept in check in this district by several parasites, both Dipterous and Hymenopterous ones". He mentioned a Braconid, a Bombylid, and a Tachinid. This is the only reference to a Bombylid as a parasite found in the literature, and the species name of it as well as of the others was not given.

A very interesting parasite is cited by Bogoljubov (1913) of the Turkestan Station. The name is not given but a description is supplied; "The females kill the caterpillars with their ovipositor, feeding on their blood and depositing eggs on the killed insect. The parasites prefer the blood of fresh victims and pass from one caterpillar to another.

In the laboratory some females have killed as many as eight caterpillars during their life and deposited on them about 100 eggs. The development of the parasite from egg to imago requires from eight to fifteen days, thus a large number of generations are bred during one summer."

This parasite might prove to be a very valuable one as a long ovipositor is needed to reach most of the larvae when they are in the corn ear. The protection offered by the shucks is probably the reason why there is very little parasitism of the larvae found on corn.

#### METHODS AND MATERIALS

Work on the collection of the parasites of H. obsoleta was started in May, 1930, as soon as the corn had sprouted. All the Lepidoptera, whether corn earworm or not that were found attacking the corn plant, were taken to the Entomology Field Insectary for rearing. By the middle of June H. obsoleta had become so numerous that all collected could not be handled and then only a representative number of about 25 was taken from each field in which collections were made. The first corn earworms were found in the bud of the young corn plant and then as the season progressed they were found on the tassel, silks and finally could only be secured by pulling the shucks from an ear.



All the collections were made from fields within a radius of five miles of Manhattan until the last of the season when larvae were obtained from Harper, Ellsworth, and Lincoln Counties.

The larvae first collected were placed separately in jelly glasses which were about one-fourth full of dirt. Tender blades of corn were added each day after examination of the larvae. As soon as the larvae became numerous small salve boxes were substituted for the jelly glasses. A folded piece of newspaper was put in the bottom of each of these. By the last of June it was very evident that the mortality was considerably higher in the boxes than in the jelly glasses. So, the first of July a larger number of jelly glasses were secured which were used with better success. The extra room and the dirt in these provided the larvae with conditions which were more natural.

A systematic record of each larva was kept and a sign made on the lid of each container told what stage the larva was in and whether or not it had been parasitized.

All the Lepidoptera attacking corn were collected in order to secure their parasites and expose corn earworm larvae to these in parasite cages. In this way it was hoped that the interrelationship of possible hosts could be studied.

Most of the collections at Manhattan were made on corn but later in the season a few were made on alfalfa, because the H. obsoleta larvae were more exposed there and had a better chance of being parasitized. On September 27, a number of larvae (Table III) were received from Mr. Dwight Patton of Harper County. Then on October 7 a collecting trip was made by the writer to Ellsworth and Lincoln Counties and a number of larvae collected on both alfalfa and kafir (Tables IV, V, VI).

When any parasites were reared, if at least one male and one female were secured, they were placed in a lamp chimney cage with a small corn earworm exposed on a blade of corn or a piece of corn ear. The parasites were fed syrup on a wad of cotton. The earworm larva was removed after one day and a new one added. This was repeated each day until the parasites had died. The removed H. obsoleta larvae were reared in similar manner to those collected from the field.

Numerous sweepings of alfalfa were made and the small parasitic Hymenoptera collected were put in cages with small corn earworms and the latter were treated as those described before.

Parasites of the smart weed borer were secured from a man working with them, and tested out in a similar manner.

During the fall of 1929 numerous beetle larvae of the Cantharidae group were collected while in the act of destroying H. obsoleta larvae. Some of these were kept over the winter and reared to maturity. As soon as it was ascertained what the beetles were, a search was made and a few were found. The females of those collected were placed individually in salve boxes about one-half full of dirt and fed syrup on corn blades. In several cases egg masses of from 150 to 200 eggs, which hatched in about ten days, were secured. Unsuccessful attempts were made to feed these small larvae and on the second day they burrowed into the ground and formed a sort of cell in which they remained. The hot dry weather during July killed all of them and during the last of August more were secured. They acted in a similar manner and are at present resting in their cells.

Orius insidiosus Say, a small Hemipteran, was found in large numbers especially on the silks of the corn ear. A large number of these, both larvae and adults, were collected and placed in vials with corn earworm eggs and also with small earworm larvae.

On four different occasions larvae of Coccinellidae were found devouring small H. obsoleta larvae. These were taken to the insectary and fed on small earworm larvae and reared to maturity.

Several Chrysopidae larvae were collected and reared to maturity on small corn earworm larvae which they readily attacked.

Many collections of H. obsoleta eggs were made. These were taken to the Insectary and placed in vials to see if any were parasitized. When the H. obsoleta hatched they were removed and as soon as the remaining eggs started to turn black or looked parasitized they were placed separately in small shell vials. In this way the number and kind of parasites were easily recorded.

When ever any egg parasites emerged they were put together in a new vial with some H. obsoleta eggs and in this way the numbers were built up and the life histories studied. The collection which was made in June was lost during July due to the absence of earworm eggs and had to be started over again as soon as the Kansas drought broke during the last of August. These were carried on until frost.

The equipment needed for these experiments was not elaborate. It consisted of half pint jelly glasses, salve boxes, shell vials and lamp chimneys for parasite cages.

#### DISCUSSION AND RESULTS

The collecting done in the vicinity of Manhattan was seriously hampered by the unusual heat and drought during July and the first half of August. Larvae were extremely

scarce and eggs were not to be found.

### Parasitism of Larvae

In all there were 786 larvae collected at Manhattan of which 614 were H. obsoleta, 550 secured from corn and 74 from alfalfa. In Table II a record of these larvae is given. This work was carried out on tables in a roofed screened insectary and was not rat-proof. On one occasion one or more rats destroyed several of the specimens as recorded under the heading "Destroyed by Rats". These insects were practically all pupae. The rest of the pupae not accounted for in the table are at present passing the winter in that stage. The table shows the insect parasitism as very small, especially on larvae on the corn. Four larvae with Tachinid eggs attached were collected from alfalfa but were not recorded under the parasitized column because they were reared to maturity. This shows that the eggs were evidently cast off with the molted skins.

The mites and nematodes, however, especially the latter, were of more importance. It was not determined whether or not these came from the soil in the jelly glasses but new larvae added to these containers were always killed

A specimen infested with these nematodes was sent to Dr. N. A. Cobb who determined them as Diplogaster aerivora Cobb. It was observed that it took these worms an average

Table II. Corn Earworm Larvae Collected on Corn at Manhattan

Place	Number :larvae :col- :lected	Pupated		Emerged		Parasi- :tized		Died								Destroyed	
		No.	cent	No.	cent	No.	cent	Fungus	Mites	Nema- :todes	All Other :Causes	As Pupa	by Rats				
		:No.:	:cent:	:No.:	:cent:	:No.:	:cent:	:No.:	:cent:	:No.:	:cent:	:No.:	:cent:	:No.:	:cent:	:No.:	:cent:
Hunter's Island	120	26:21.7	21:17.5	1 : .8	1 : .8	1 : .8	1 : .8	2 : 1.7	91:75.8	3 : 2.5	2 : 1.7						
Agronomy Farm:	41	19:46.4	14:34.2	0 : 0	0 : 0	0 : 0	0 : 0	0 : 0	22:52.6	0 : 0	3 : 7.3						
Pottawatomie County	83	49:59.1	32:38.6	1 : 1.2	0 : 0	0 : 0	0 : 0	4 : 4.8	33:39.8	5 : 6	6 : 7.2						
Field	53	17:32.1	11:20.8	0 : 0	0 : 0	0 : 0	0 : 0	0 : 0	36:68	2 : 37.7	0 : 0						
Insectary																	
Ashland	35	16:45.7	10:28.6	0 : 0	0 : 0	0 : 0	0 : 0	2 : 5.7	19:54.3	3 : 8.6	1 : 2.8						
Prof. Dicken's Farm	23	20:87	15:65.3	0 : 0	0 : 0	0 : 0	0 : 0	5 : 21.7	3:13.1	2 : 8.7	0 : 0						
Moehlman Bottoms	68	53:78	39:51.4	0 : 0	0 : 0	0 : 0	0 : 0	8 : 11.7	15:22.1	3 : 4.4	3 : 4.4						
Manhattan Hatchery	56	6:10.7	2 : 3.6	0 : 0	1 : 1.8	5 : 8.9	0 : 0	0 : 0	49:87.5	4 : 7.2	0 : 0						
Wabaunsee County	10	3:30	3 : 30	0 : 0	0 : 0	0 : 0	0 : 0	0 : 0	7:70	0 : 0							
Miscellaneous:	61	12:19.7	9 : 14.8	0 : 0	0 : 0	0 : 0	2 : 3.3	0 : 0	41:67.3	1 : 1.6	9 : 14.8						
TOTAL	550	221:40.2	156:28.3	2 : .36	2 : .36	8 : 1.4	21 : 3.8	316:57.4	23 : 4.2	24 : 4.3							

Corn Earworm Larvae Collected on Alfalfa at Manhattan

Agronomy Farm:	41	16:39	7:17.1	2 : 4.9	0 : 0	0 : 0	0 : 0	1 : 2.4	22:53.6	2 : 4.9	7 : 17.1						
Pottawatomie County	10	7:70	3:30	0 : 0	0 : 0	0 : 0	0 : 0	0 : 0	3:30	0 : 0	2 : 20						
Field	12	5:41.6	3:25	0 : 0	0 : 0	0 : 0	0 : 0	0 : 0	4:33.3	0 : 0	3 : 25						
Insectary																	
Miscellaneous:	11	2 : 18.4	0 : 0	0 : 0	0 : 0	0 : 0	0 : 0	1 : 9.1	5:45.5	0 : 0	5 : 45.5						
TOTAL	74	30:40.6	13:17.6	2 : 2.7	0 : 0	0 : 0	0 : 0	2 : 2.7	34:46	2 : 2.7	17 : 23						

of eight days to kill a H. obsoleta larvae and then it was another seven days before they ate their way out through the body wall where they were noticed.

In answer to an inquiry about an infestation of H. obsoleta on alfalfa in Harper County made by Mr. Dwight Patton some containers were sent to him in which he returned 70 larvae collected from alfalfa. These were very heavily parasitized as shown in Table III.

Table III. Corn Earworm Larvae Collected on Alfalfa in Harper County

Pupa		Parasitized				Died			
Pupa		Microplitis		Tachinidae		Fungus		All other	
No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
70	3	37	52.9	1	1.4	6	8.6	23	32.9

The fungus reported as killing some of the larvae was very characteristic in its action and the symptoms were always the same. Upon death the larvae were very firm and seemed to be stretched lengthwise to their utmost extent. Then on the second day a white fungus appeared all over their bodies.

The larvae taken on October 7 from Ellsworth and Lincoln Counties were heavily parasitized as compared to those taken earlier in the year from corn and alfalfa. These results are given in Tables IV, V, and VI.

Table IV. Corn Earworm Larvae Collected on Kafir in Lincoln County

		Pupa		Parasitized		Died	
		Microplitis croceipes		Microplitis sp.		All Other Causes	
Total:	No.:	Per cent:	No.:	Per cent:	No.:	Per cent	
30	5	16.7	21	70	4	13.3	

Table V. Corn Earworm Larvae Collected on Alfalfa in Lincoln County

		Parasitized		Died		
		Microplitis croceipes		Microplitis sp. near Melianae		
Total:	No.:	Per cent:	No.:	Per cent	No.:	Per cent
72	39	54.2	3	4.2	30	41.7

Table VI. Corn Earworm Larvae Collected on Alfalfa in Ellsworth County

		Pupa		Parasitized		Died		
		Microplitis croceipes		Microplitis sp. near Melianae		All Other Causes		
Total:	No.:	cent:	No.:	cent	No.:	cent:	No.:	cent
216	2	.9	116	53.7	11	5.1	18	8.3
							69	31.9

Table VII gives a total parasitism of the H. obsoleta larvae taken from the different places.



Table VII. Total Parasitism of H. obsoleta Larvae

Collected: on	:	:	Died							
			Parasitized:		Fungus		All Other Causes			
	:	Total:	No.:	Per cent:	No.:	Per cent:	No.:	Per cent		
Corn	:	550	:	2:	.4	:	2:	.4	:316:	57.5
Alfalfa	:	432	:	209:	48.4	:	24:	5.6	:156:	36.1
Kafir	:	30	:	21:	70.0	:	0:	0	: 4:	13.3
Total	:	1012	:	232:	22.9	:	26:	2.6	:476:	47.1

### Egg Parasitism

The drought affected the work on the egg parasitism more than it did the larval. A small collection of parasites was made in June but these were lost due to lack of eggs during July and the first part of August. After that another collection was made and kept until frost when eggs again became scarce.

The first part of Table VIII gives the total amount of parasitism and the species; the second compares the species as to percentage, and the third compares them from the point of number of collections made.

### Miscellaneous Enemies of the Corn Earworm

None of the 39 attempts to parasitize H. obsoleta with parasites of other insects made by confining the earworm larvae in cages with those parasites was successful. However, one H. obsoleta larvae that had been confined in a cage with some Phoridae (Diptera) parasites had a

Table VIII. Parasitism of Corn Earworm Eggs at Manhattan

Date	Place	Total	Number infested	Kind of Parasite	Per cent
6-16-30	Collins' Farm	38	12	<u>Telenomus heliothidis</u> Ashm.	30.52
6-18-30	Hunters Island	70	0	<u>Telenomus heliothidis</u> Ashm.	0
6-30-30	Hunters Island	130	6	<u>Trichogramma minutum</u> Riley	4.62
			56	<u>Telenomus heliothidis</u> Ashm.	43.07
8-20-30	Pottawatomie County (Two miles east of bridge)	13	0	None	0
8-25-30	Field Insectary	50	0	None	0
8-25-30	Agronomy Farm (West of Sewell's plots)	110	1	<u>Telenomus heliothidis</u> Ashm.	0.9
8-25-30	Agronomy Farm (Field south of alfalfa plots)	80	5	<u>Telenomus heliothidis</u> Ashm.	6.25
8-25-30	Moehlman Bottoms	20	0	None	0
8-26-30	Hunters Island (One mile south Collins' farm)	75	8	<u>Telenomus heliothidis</u> Ashm.	10.67
8-26-30	Hunters Island (Field west of Collins')	60	4	<u>Telenomus heliothidis</u> Ashm.	6.67
8-27-30	Field Insectary	20	2	<u>Telenomus heliothidis</u> Ashm.	10.
8-27-30	Popcorn patch	75	3	<u>Telenomus heliothidis</u> Ashm.	4
8-28-30	Pottawatomie County	100	2	<u>Telenomus heliothidis</u> Ashm.	2
8-28-30	Jones' Cabin	100	0	None	0
8-28-30	Ashland	70	0	None	0
9- 2-30	Field Insectary	95	0	None	0
9-17-30	Ashland	110	41	<u>Trichogramma pretiosa</u> Riley	37.27
9-19-30	Ogden	84	3	<u>Telenomus heliothidis</u> Ashm.	3.57
			60	<u>Trichogramma pretiosa</u> Riley	71.43
9-19-30	S. E. Junction City	24	6	<u>Telenomus heliothidis</u> Ashm.	25
9-22-30	S. E. Junction City	217	15	<u>Trichogramma pretiosa</u> Riley	6.91
10-10-30	Hunters Island	128	11	<u>Trichogramma pretiosa</u> Riley	8.59
			5	<u>Telenomus heliothidis</u> Ashm.	3.90
Total		1669	240		14.38

## Species Compared

Total number of eggs collected	Number of eggs infested	Parasite	Per cent
1669	127	<u>Trichogramma pretiosa</u> Riley	7.6
1669	107	<u>Telenomus heliothidis</u> Ashm.	6.4
1669	6	<u>Trichogramma minutum</u> Riley	.4

Parasitism of Twenty-one Collections of *H. obsoleta* eggs

Number of collections infested	Parasite	Per cent
4	<u>Trichogramma pretiosa</u> Riley	19.1
12	<u>Telenomus heliothidis</u> Ashm.	57.1
1	<u>Trichogramma minutum</u> Riley	4.5

\*Later determined as Trichogramma minutum Riley.

Hymenopterous parasite emerge from it. That larvae had no doubt been parasitized before being placed in the cage.

The Cantharids collected during the fall of 1929 were very active and able to kill a large H. obsoleta larva. Especially was this true where the beetle larvae followed its prey into a tunnel in a corn ear where the earworm could not be very active due to lack of room. These beetle larvae had the peculiar habit when disturbed of casting off a milky secretion from ducts along the sides of the abdomen. There seemed to be two of these ducts to each segment, one on each side. They lived over the winter in the soil in their glass containers without any food. The first adult emerged on June 26, and has been identified as Chauliognathus marginatus Fabr.

The lady bird beetle larvae collected and reared to maturity on small H. obsoleta larvae were Ceratomegilla fuscilabris Muls. and Hippodamia convergens Muls. They were quite active and were often observed on the corn plant. They were running up and down the stalk and over the ears evidently in search of prey which was often earworm larvae since they were the most numerous of any larvae on the corn. When a larvae was found an attack was made on it and in a short time it was devoured.

Chrysopa plorabunda Fitch was the species of Neuroptera reared to maturity on H. obsoleta larvae. These were not

numerous and probably kill only a few earworm larvae. However, they are well equipped for a predacious life and readily destroyed the larvae fed them while confined in a cage.

The insect enemies of most importance in Kansas seem to be the egg parasites, Telenomus heliothidis Ashm and Trichogramma minutum Riley, and the Hymenopteron, Microplitis croceipes (Cress) which parasitizes the earworm larvae.

Telenomus heliothidis Ash.

These insects mated readily and immediately began ovipositing on the eggs furnished them in the parasite vials.

In studying T. heliothidis it was noted that the female had a characteristic method of approaching the egg. With fast movements of the antennae the egg is felt over until a suitable spot is found. Then the antennae is folded in front of the head, the prothoracic legs are also folded, the mesothoracic legs are extended at length to push the anterior end of the insect as far as possible from the egg, the metathoracic legs are folded on the egg thus leaving the insect at an angle of almost 90° from the egg. The wings are then slightly spread and extended over the side of the egg and the ovipositor is inserted. Time for ovipositing was observed on two T. heliothidis with the

following results of each;

Female No. 1

Oviposition No. 1.	Two minutes, 30 seconds	) Same egg
Oviposition No. 2.	One minute, 20 seconds	
Oviposition No. 3.	Two minutes, 15 seconds	
Oviposition No. 4.	Two minutes, 50 seconds	

Female No. 2

Oviposition No. 1.	One minute, 35 seconds
Oviposition No. 2.	One minute, 30 seconds

After the ovipositor is withdrawn it is stroked violently in all directions on the host shell evidently cleaning it on the ridges of the egg. Also the females often stroke their wings with their legs after the ovipositor has been cleaned.

Since in no case did more than one parasite emerge from one egg, there was evidently only one egg laid in each H. obsoleta egg. The T. heliothidis larvae feed entirely within the earworm egg and emerged as a mature adult. The time required for development varied from 12 to 32 days. The conditions of moisture and temperature should have been the same for all the eggs in each vial so some other factor must have caused this variation.

It was observed that the mated individuals did not live as long as the isolated males and females if the latter were fed. These would feed ravenously on the syrup placed on the cork of the vial in which they were confined. These unmated individuals averaged about 21 days but the record

for length of life was 40 days for one individual.

In dealing with the mated individuals it was found that the males died soon after mating and the females shortly after ovipositing. On an average the latter lived from three to five days with one occasionally going for ten days.

Mr. W. P. Hayes did some earlier work at the Experiment Station at Manhattan on the hibernation of T. heliothidis. He found that this insect overwinters in the egg of H. obsoleta if November 8 can be considered late enough for hibernation to have occurred. However, the exact overwintering stage was not determined. On that date some earworm eggs were collected and placed in a parasite box in the greenhouse insectary and on November 22 one male of T. heliothidis emerged and on December 18 four females emerged.

#### Trichogramma minutum Riley

As soon as T. minutum were placed in the vial cages they mated. They acted in a similar manner to Telenomus whenever the females found any H. obsoleta eggs. They would crawl around over the eggs tapping them with their antennae until a suitable spot was found. Then the thin ovipositor was inserted and the eggs deposited. This process required about two minutes for each egg. As soon as the ovipositor was withdrawn the parasite was ready to oviposit on another egg. The position taken in oviposition

was similar to the one assumed by Telenomus.

On the third day after being parasitized the H. obsoleta eggs rapidly became darker and finally turned to a bluish color. This coloration persisted even after the parasites had emerged and always served to distinguish a parasitized egg.

The developmental period from time of oviposition to emergence from the host egg varied from eight to ten days. The number of parasites emerging from each egg varied from one to four with an average of 2.5. This was determined by placing 50 of the parasitized eggs separately in small shell vials.

The adults seemed to feed but very little if any on the syrup offered them on the cork to their vial. Their average length of life was about one and one-half days, but this sometimes reached a maximum of four.

#### Microplitis croceipes (Cress)

This parasite was very numerous among the larvae collected from Harper, Ellsworth and Lincoln Counties. A total of 176 earworm larvae out of 318 were parasitized, which is a percentage of 55.3.

The action of a parasitized corn earworm was characteristic. By the time the parasite grub is full grown the larvae has shrunk to about one inch in length and acquired

a pale yellowish color, and has stopped feeding. Within the next half day the parasite emerges leaving a small black scar. The earworm larvae lives for several days but does not feed any more and gradually dries up. Upon emergence the parasite grub spins an oval cocoon about 5 or 6 mm. in length and having several coarse longitudinal ribs. At first the cocoon is almost white but soon turns to a dingy yellow and gets very tough. The adult parasite emerges by cutting a cap off the end of the cocoon. Only three of the 176 collected at Manhattan emerged and the rest are in their cocoons.

The following description of this insect is given by Quaintance and Brues (1905) under the name M. nigripennis, which is a synonym of M. croceipes: "Length, 4 to 5 mm. Black, except the abdomen and legs, which are usually reddish yellow. Wings very strongly infuscated. Antennae 17 jointed. Head and thorax shining black, metathorax coarsely reticulated, with median carina. Abdominal petiole black at base and remainder of abdomen sometimes much darkened. Legs reddish, the coxae more or less black at base. Wings very dark, veins blackish, second cubital cell about as high as long, subtriangular."



Orius insidiosus (Say)

Among the predators Orius insidiosus is probably the most beneficial. This is a vicious little insect as evidenced by the writer who on several different occasions was bitten by the adults.

Their detailed life history is given by Marshall (1930) in his paper on Orius insidiosus. He did his work at this Station so it need not be repeated.

These insects, both adults and nymphs, were very numerous on the corn silks and corn ear in the field. It was assumed that a large number of the empty H. obsoleta egg shells found on the silks were due to them. Since the eggs were white they had not been parasitized by the egg parasites and had they hatched, these egg shells would have been eaten by the young earworm larvae. The predacious habit of Orius insidiosus was further proved by the fact that several collections of both nymphs and adults were made and that in both cases they readily attacked H. obsoleta eggs and small larvae given them under cage conditions.

Quaintance and Brues (1905) found that 55 per cent of the eggs and many of the small larvae of the corn earworm were destroyed by O. insidiosus. When eggs are attacked, the beak is thrust through the shell and the contents extracted. The same thing happens when live insects are

captured.

#### SUMMARY

1. Heliothis obsoleta Fabr. is an omnivorous insect annually doing many millions of dollars of damage. Since it seems that no wholly satisfactory method of control can be developed, parasites may be the solution of the problem.

2. The corn earworm has 82 reported insect enemies reported in the literature. These represent five orders, including 46 species of Hymenoptera, 22 of Diptera, 8 of Hemiptera, 5 of Coleoptera and 1 of Neuroptera.

3. Two new species of insect enemies of the corn earworm were found at the Kansas Station. These are Chrysopa plorabunda Fitch and Microplitis sp., near melinae Vier.

4. The most important enemies in this section of Kansas are the egg parasites, Trichogramma minutum Riley and Telenomus heliothides (Ashm.); the larval parasite Microplitis croceipes (Cress) and the predacious bug Orius insidiosus (Say).

5. The parasitism on corn is very small. This shows that a parasite is needed with a long ovipositor with which it can reach the H. obsoleta larvae through the shucks.

6. A parasite like that reported by Bogoljubov (1913) is the best type and might prove to be valuable if introduced.

7. It is not expected that any single parasite will ever be able to control H. obsoleta.

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