U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 73.

L. O. HOWARD, Entomologist and Chief of Bureau.

STUDIES OF PARASITES OF THE COTTON BOLL WEEVIL.

BY

W. DWIGHT PIERCE,

Special Field Agent.

Issued January 21, 1908.

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COTTON BOLL WEEVIL INVESTIGATIONS.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., July 29, 1907.

Sir: I have the honor to transmit herewith a manuscript entitled "Studies of Parasites of the Cotton Boll Weevil," by Mr. W. Dwight Pierce, a special field agent of this Bureau engaged in cotton boll weevil investigations. Some of the preliminary results of these studies were published as Bulletin No. 63, Part II, of the Bureau of Entomology, under the title "Notes on the Biology of Certain Weevils Related to the Cotton Boll Weevil." The boll weevil in the United States is now known to be attacked by several species of parasitic insects. These have not been introduced with the boll weevil from the country from which the latter spread, but they have been here for years as parasites of other species of weevils occurring in the territory now infested by the boll weevil. The present manuscript contains a record of investigations of these parasites and deals especially with the possible practical applications which may be made of the results gained. I recommend its publication as Bulletin No. 73 of this Bureau.

Respectfully,

L. O. Howard,
Entomologist and Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

PREFACE.

The boll weevil has been present in the United States for fourteen years. At this time it is doing serious damage to cotton in four States, and during the present season undoubtedly will invade a fifth. In regions like Central America, where the insect has existed for many years, there are various influences that serve to hold it in check. In this country similar influences are beginning to be in evidence. Among the direct factors in the natural control of the boll weevil that are now at work are the following: Heat and dryness, the native ant *Solenopsis geminata*,[a] winter temperatures, proliferation, parasites, defoliation by the cotton leaf-worm, determinate growth, and birds. Of these, proliferation and birds have already received careful special attention, while the work of the native ant has received preliminary notice. The other factors have also been more or less discussed in the publications of the Bureau of Entomology and elsewhere, and more extensive studies of certain ones will be discussed by Dr. W. E. Hinds in Bulletin No. 74 of this Bureau.

While the work of parasites, discussed in this bulletin, is not at present one of the most important factors in the control of the boll weevil, the indications are clear that its importance will grow rapidly. Moreover, the matter has special interest for the reason that it is not unlikely that practical means may be devised to increase the work of the parasites.

In the United States fifteen species of insects which seek the weevil in its immature stages are known. These insects have not been introduced artificially from other countries, nor have they followed the boll weevil into this country. They have all been present for years, and have been actively parasitic upon other species of weevils found within the boll-weevil-infested territory. In fact, there are a great many closely related weevils of the genus Anthonomus, some of which are very common in parts of the cotton belt. These weevils are frequently held completely in control by parasites, and for the most part the parasites are not confined to the attack of a single species of weevil. In many cases the boll weevil may appear in a

[a] Not to be confused with the kelep, the introduction of which has proved unsuccessful.

region in which the parasites have reached the critical point of maximum parasitism, and in such cases the overflow of parasites must attack some other host, which naturally will be the predominant insect of the same group as their former host. It is therefore not at all surprising that when the boll weevil appears by millions in a new region these same parasites in the very first generation of the boll weevil become adapted to it as a new host.

The distribution of the other species of weevils is limited to floral or geographical regions, and consequently, to a less extent, the parasites are also limited. This condition is illustrated by the distribution of the species of parasites which have already attacked the boll weevil. It is safe to say that as the pest advances to the East and North still other insects will adopt it as their host in the same measure as it invades regions inhabited by other species of weevils. In many transitional regions there is a strong possibility that several species of weevils may be very highly parasitized and that all of them will lend parasites to the attack of the boll weevil. In such regions especially there are to be expected instances of very high percentages of parasitism. At Waco, Tex., where two regions border upon each other, a parasitism of over 40 per cent occurred at one time during the season of 1906.

There are two possible practical applications of the information obtained and recorded in this bulletin, both, however, requiring expert entomological knowledge and experience. These are: (1) The propagation and collection of parasites, and their distribution in regions where the same species are either present in but small numbers or altogether absent, and (2) the elimination of related weevils by the destruction of their food plants in or about cotton fields, thereby forcing the parasites to transfer their attention to the boll weevil.

Under the plan of artificial propagation by picking large numbers of squares in fields where the weevil is highly parasitized and placing them in cages adapted for such breeding, a large number of parasites might be obtained. The weevils should then be killed. These parasites could be released in fields with a low percentage of parasitism, and the results under favorable conditions should be apparent after one generation of the boll weevil. In this bulletin will be found an account of an apparently very successful experiment of this kind, in which, at Dallas, Tex., the percentage of parasitism was brought up 9.1 per cent by the introductions of parasites from Waco, about 100 miles away.

Under the plan of eliminating, more or less, the natural hosts of parasites that will attack the boll weevil (by the destruction of their food plants) no experiments have yet been performed. As an example of the possibilities, however, it may be mentioned that there is a common but easily controlled weed (*Croton* spp.) grown in and about cotton fields throughout the South the seed pods of which are infested by a weevil (*Anthonomus albopilosus*) closely allied to the boll weevil. This weevil has three different parasites, which also attack the boll weevil. The croton weevil does not feed upon cotton or any other cultivated plants. By merely mowing down or otherwise removing the croton plants at the proper time there could be no danger from the croton weevil, while its parasites would be forced to turn their attention to the boll weevil. It is conceivable that the encouragement of the croton plants or the actual planting and later removal might be undertaken in order to obtain the best possible results.

Other results of practical application are recorded in this bulletin. Among them may be mentioned the fact that fallen forms exposed to the sun show higher parasitism than those shaded, due undoubtedly to the light-loving character of the parasites. This gives another reason for the wide spacing of the plants and the use of varieties of cotton with the minimum tendency to form leafage and the greatest tendency to shed their leaves in the fall.

W. D. HUNTER,
In Charge of Cotton Boll Weevil Investigations.

CONTENTS.

ILLUSTRATIONS.

PLATES.

TEXT FIGURES.

STUDIES OF PARASITES OF THE COTTON BOLL WEEVIL.

INTRODUCTION.

Although the boll weevil (*Anthonomus grandis* Boh.) has shown adaptation to many diverse conditions, it is not free from parasites. From the work detailed in this bulletin it has become apparent that certain enemies attack it in arid regions and certain others in humid regions; that some species attack principally larvæ in dried or sun-exposed forms, while other species attack the weevil stages in moist, decaying forms; that some species work most readily in prairie country, while others prefer woodland. The weevil does not escape parasitism by dispersion, for the local parasites are capable of adaptation and attack the boll weevil in its first generation.

Being a species with an all-season food plant, *Anthonomus grandis* has made a decisive gain over most of its near relatives, which are confined to more or less limited periods because of the shorter seasons of their host plants. The most active weevil parasites in the South have become adjusted to one host after another until in most localities they have a regular seasonal rotation of hosts. From this multiplicity of parasitic relations it is but natural to evolve a new tendency and to attack the most abundant species of the locality, namely, the boll weevil.

As the native weevil hosts are more or less limited in distribution, it is found that the boll-weevil parasites are likewise geographically restricted. The combined activity of two or more species in certain favored districts has been the cause of forming three known centers of intensive parasitism in Texas, of which the most important is near Waco; the next around Goliad, Cuero, and Victoria, and the third in eastern Texas. The agencies forming these centers are in no case identical. *Catolaccus incertus* is the most active parasite at Brownsville, Tex., and Orange, La. *Bracon mellitor* (fig. 1), which is the predominant parasite for the entire infested area, is the most active in the entire western half of Texas. *Cerambycobius cyaniceps* is predominant in northeastern Texas. *Eurytoma tylodermatis* shows its greatest activity at Overton and Dallas.

HISTORY.

Prior to the year 1906 very little information concerning the parasites of the boll weevil had been accumulated. In 1895 Townsend mentioned a small hymenopterous parasite; also recorded the suspicious occurrence of several species of Scymnus in the squares, and mentioned that a fungoid parasite, a species of Cordyceps, "was found growing out of a dead pupa in its cell in a boll, November 26, in a field in San Juan Allende, Mexico." (Townsend, 1895.)[a] In 1896 Doctor Howard stated that the parasites were only abundant late in the fall and that from "15 to 20 per cent of the weevil larvæ in fallen squares in November at Beeville and Kenedy were destroyed by parasites." (Howard, 1897.)

FIG. 1.—*Bracon mellitor*, parasite of boll weevil. Much enlarged (from Hunter and Hinds).

In 1901 Professor Herrera published a preliminary note concerning *Pediculoides ventricosus* Newp. (fig. 2) (Rangel, 1901b, p. 206), and in the same year a more extensive note on the work of this mite was published by Rangel. In testing the mite's ability to propagate, 250 squares were divided into lots of 50 each and an infested larva placed with each lot for four days. One hundred check squares were used. At the time of examination the check squares were free from the mites, while the others contained 193 weevil stages, of which 61 were attacked by Pediculoides; in other words, 31.6 per cent were parasit-

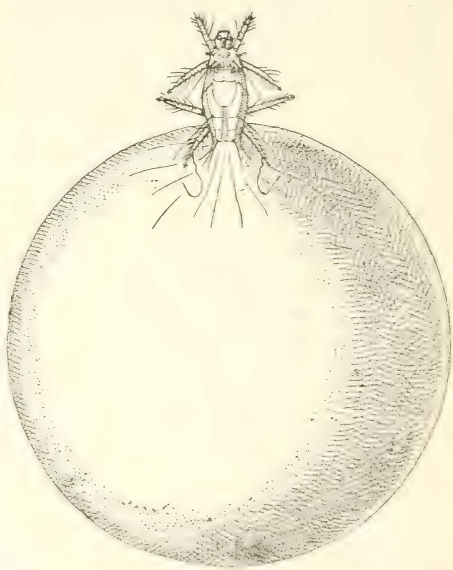


FIG. 2.—*Pediculoides ventricosus*, mite enemy of boll weevil. Much enlarged (adapted from Brucker).

[a] Bibliography, pp. 50–51.

ized. A small field test proved that the mites increased and spread (Rangel, 1901c).

In 1902 Dr. Wm. H. Ashmead described *Bruchophagus herreræ*, from Coahuila, Mexico, as a primary parasite of the boll weevil (Ashmead, 1902). In the same year Prof. F. W. Mally recorded the fact that *Bracon mellitor* Say and *Cerambycobius* (*Eupelmus*) *cyaniceps* Ashm. had, since 1899, been bred by him in considerable numbers from the weevil. He also recorded a species of Eurytoma (Mally, 1902). In 1904 Hunter and Hinds recorded additional primary parasites as follows: *Sigalphus curculionis* Fitch (fig. 3), *Catolaccus incertus* Ashm., *Urosigalphus* (*robustus* Ashm.), *Bracon* (*dorsator* Say), and *Eurytoma tylodermatis* Ashm., as well as an entomogenous fungus, *Aspergillus* sp. (Hunter and Hinds, 1904, pp. 104–110). The determination of this Urosigalphus has been found incorrect. It has just been described as *Urosigalphus anthonomi* Cwfd. (Crawford, 1907a). The form known under the name of *Bracon dorsator* is merely a small, melanistic, fall form of *Bracon mellitor* Say. Finally, Banks has described a mite, *Tyroglyphus breviceps*, collected at Victoria, Tex., from boll weevil larvæ (Banks, 1906, p. 17).

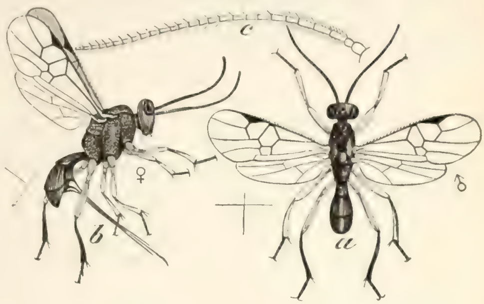


FIG. 3.—*Sigalphus curculionis*: *a*, male; *b*, female; *c*, antenna. All enlarged (after Riley).

THE WORK ON PARASITES IN 1906.

As the work of the year naturally divided itself into distinct sections, it may be thus divided for treatment in this report:

I. Examination work—ascertaining the general status of boll weevil parasitism.
II. Propagation work—attempting to increase the percentage of parasitism by release of parasites.
III. Breeding work—study of the biology of the parasites.
IV. Source work—study of the surrounding field conditions in order to ascertain the hosts which have contributed the parasites, and to learn the biology of each of these hosts.
V. Conclusions—a review of the situation as a whole.

I. EXAMINATION WORK.

In order to arrive at a proper knowledge of the status of boll weevil parasitism large collections of infested squares and bolls under various plant and field conditions were made in many parts of the weevil territory. This material was immediately shipped to the laboratory and examined by the various members of the laboratory force. Messrs. Hinds, Bishopp, Crawford, Cushman, Jones, Morgan, Pratt, and Yothers were engaged at various times in the collection of infested material and the more important work of examination. Upon their accuracy of observation the finding of the parasites was dependent, and to them belongs credit for the amount of figures herewith presented relating to the percentage of parasitism. A careful tabulated record was kept of all stages of the weevil, alive or dead, and all parasites were isolated in tubes. Each collecting lot received a number and each individual a sub-number, and its stage and the nature of its parasitism were recorded. As each parasite matured the record was placed opposite its number, and the insect was either used in experiments or laid aside for the collection. In this manner there could seldom be an error as to the nature of the parasitism, as all evidence was in the tube.

RECORDS PRIOR TO 1906.

In previous years no regular method of making the parasite records was in use, and consequently there is difficulty in the comparison of the former conditions with those now prevalent. In some cases the percentage was obtained from the breeding records only, and at other times by an examination for the total number of stages present.

In 1902 three observations were made between July 31 and August 11 at Calvert, Guadalupe, and Victoria. The figures obtained included only bred stages, omitting consideration of stages killed by heat, fungi, ants, crushing, etc.

In 1903 Dr. A. W. Morrill first pointed out in his notes that parasites occur in dry hanging forms,[a] and also in bolls. No other mention of the former condition can be found prior to 1906. Only two observations were made, both being at Victoria, in June.

In 1905 four examinations of bolls were made during March, at Calvert, Palestine, Runge, and Victoria, in order to ascertain the condition of hibernating stages. These examinations consider the total number of stages found hibernating in the bolls. The figures are important, as they prove that the parasites also hibernate in bolls.

During August of the same year nine examinations were made at Gurley, Quinlan, Victoria, and Waco. These figures were obtained from fallen forms and included the total number of stages in the forms.

In 1902 and 1903 the figures obtained must give a higher percentage of parasitism than actually occurred, as no account was taken of the stages dead from other causes. It is also very unsatisfactory to take the entire percentage of parasitism in all forms on account

[a] The term "forms" has been used to designate a mixture of squares and bolls.

of the differences which prevail between squares and bolls and between fallen and hanging squares or bolls. However, taking the figures as they are, we have the following results:

TABLE I.—*Total percentage of parasitism of the boll weevil, by years, prior to 1906.*

Year.	Months.	Weevil stages.	Parasites.	Percentage of parasitism.
1902	July 31 to August 11	601	6	0.99
1903	June 3 to 9	178	6	3.37
1905	March 1 to 23 (hibernating)	1,005	32	3.18
1905	August 12 to 31	1,702	21	1.23

In 1905 some of the records differentiated between squares and bolls, so that a comparison may be given between the percentages of parasitism in each.

TABLE II.—*Percentage of parasitism of the boll weevil in fallen forms at Gurley, Quinlan, Victoria, and Waco, Tex., in 1905.*

Form.	Weevil stages.	Parasites.	Percentage of parasitism.
Squares	852	17	1.99
Bolls	123	1	.81

BREEDING RECORDS OF 1906.

Although the work of 1906 was very incomplete in some respects, it is representative of the conditions. The facts have been ascertained one at a time, and as each one has been proved, it has been found that more complete records should have been taken earlier in the season. The material was collected at 25 representative localities in Texas, 2 in Indian Territory, and 5 in Louisiana. Seventy collections of infested forms were made, comprising about 87,000 bolls and squares. The result is that these infested forms contained 39,183 weevil stages, of which 1,689, or 4.31 per cent, were parasitized. The material collected was separated into lots, according to location and the nature of the forms.

A brief classification of the results, by months and by the four plant conditions, gives some very important information. In the first place, the percentage of parasitism is, to all intents and purposes, about equal throughout the season and not highest in the fall. It must, of course, be borne in mind that the collections were not made at regular intervals at stated places, but are from different localities each month and include different factors. During September and October a number of localities on the extreme border line were examined, but the percentage is not appreciably altered. The plant conditions were altered also, so that one month there might be more squares than bolls, and another month more bolls than squares, examined. A correct view of the monthly variation may be obtained by an examination of the complete tables of observations, which are given on succeeding pages. It will be noticed in that connection that there is no graduated seasonal wave of parasitism. Other and still unknown factors enter into the problem.

The following summary also discloses the fact that hanging forms provide conditions superior to those afforded by fallen forms, and that squares are more favorable than bolls.

Finally, it appears by comparison with the table of results for previous years that there has been a gain in the total percentage of parasitism as well as in the two classes of forms.

TABLE III.—*Percentage of parasitism of the boll weevil, by months, in 1906.*

Month.	Fallen squares.			Hanging squares.			Fallen bolls.			Hanging bolls.			Total.		
	Stages.	Parasites.	Per cent.	Stages.	Parasites.	Per cent.	Stages.	Parasites.	Per cent.	Stages.	Parasites.	Per cent.	Stages.	Parasites.	Per cent.
1906.															
June	3,831	118	3.08	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	3,831	118	3.08
July	4,621	210	4.54	247	76	30.76	169	0	0.00	22	0	0.00	5,059	286	5.65
August	10,342	174	1.68	2,973	348	11.70	2,490	20	.80	2,925	192	6.54	18,730	734	3.91
September	5,665	286	5.04	1,883	117	6.26	1,591	23	1.44	1,140	67	5.87	10,279	493	4.79
October	347	8	2.30	20	0	0.00	57	1	1.75	860	49	5.69	1,284	58	4.51
Entire season	24,806	796	3.20	5,123	541	10.56	4,307	44	1.02	4,947	308	6.22	39,183	1,689	4.31

[a] No records made.

The observations for June were made only at Victoria; those for October were made at Dallas for hanging forms and at Mineola for fallen forms.

Owing to the extensiveness of the tables the figures are considerably condensed, but still retain the value of their records. Numerous cases of high parasitism were found, of which the following may be cited as notable examples:

	Number of stages.	Per cent parasitized.
Fallen squares:		
Roosevelt, Tex.,[a] September 24	69	14.4
Brownsville, Tex.,[a] September 5	1,147	12.4
Hanging squares:		
Waco, Tex., July 25	99	52.6
Waco, Tex., September 20	109	23.8
Cuero, Tex., August 31	347	21.3
Fallen bolls:		
Corsicana, Tex., September 18	34	5.9
Junction, Tex., September 24	17	5.8
Hanging bolls:		
Marshall, Tex., August 22	52	13.5
Trinity, Tex., August 9	142	12.0
Waco, Tex., September 20	303	11.8

[a] In both of these localities fallen squares would naturally be dry.

Numerous other high percentages were found, but these will convey an impression as to the promises of success obtained.

In the table herewith presented only the totals for each locality are given, and in more specific tables the seasonal variation at given localities will be recorded separately.

MOST FAVORABLE PLANT CONDITIONS FOR PARASITISM OF THE BOLL WEEVIL.

TABLE IV.—*Most favorable plant conditions for parasitism of the boll weevil.*

Locality.	Season.	Squares fallen.			Squares hanging.			Bolls fallen.			Bolls hanging.			Totals.		
		Stages.	Parasites.	Per cent of parasitism.	Stages.	Parasites.	Per cent of parasitism.	Stages.	Parasites.	Per cent of parasitism.	Stages.	Parasites.	Per cent of parasitism.	Stages.	Parasites.	Per cent of parasitism.
TEXAS.	1906.															
Brownsville	July 28–September 29.	3,095	202	6.5	....	....	....	384	13	3.3	....	....	....	3,479	215	6.1
Beeville	July 12–September 3.	2,660	36	1.3	....	....	....	324	0	0.0	....	....	....	2,984	36	1.2
Corpus Christi	July 10	438	39	9.0	....	....	....	20	0	0.0	....	....	....	458	39	8.5
Goliad	August 7–September 3.	821	70	8.5	209	29	13.8	133	3	2.2	265	13	4.9	1,428	115	8.0
San Antonio	August 15	33	0	0.0	....	....	....	....	....	....	....	....	....	33	0	0.0
Kerrville	August 26–September 3.	38	4	10.5	....	....	....	295	7	2.3	....	....	....	333	11	3.3
Roosevelt	September 24	69	10	14.4	....	....	....	74	0	0.0	....	....	....	143	10	6.9
Junction	do	129	11	8.2	....	....	....	17	1	5.8	....	....	....	146	12	8.2
Mountain Home.	September 13	93	0	0.0	....	....	....	....	....	....	....	....	....	93	0	0.0
Lula	September 26	95	0	0.0	....	....	....	....	....	....	....	....	....	95	0	0.0
16 miles south of Roosevelt.	September 25	81	2	2.4	....	....	....	9	0	0.0	....	....	....	90	2	2.2
Cuero	August 9–31	1,059	11	1.0	439	87	19.9	80	0	0.0	189	2	1.0	1,767	100	5.5
Hallettsville	August 9–30	1,040	5	0.4	401	37	9.2	93	1	1.0	295	11	3.7	1,829	54	2.8
Victoria	June 16–September 1.	6,557	203	3.0	802	82	10.2	162	0	0.0	201	1	0.5	7,722	286	3.7
Taylor	August 16	153	1	0.6	160	8	5.0	63	1	1.5	40	1	2.5	416	11	2.6
Waco	July 25–September 20.	1,508	128	8.4	460	126	27.3	283	5	1.7	746	83	11.1	2,997	342	11.4
Calvert	August 22–September 13.	1,054	15	1.4	81	8	9.8	347	0	0.0	181	12	6.6	1,663	35	2.1
Corsicana	August 23–September 18.	16	0	0.0	102	12	11.7	34	2	5.9	176	6	3.4	328	20	6.0
Palestine	August 10–September 4.	1,054	14	1.3	414	48	11.5	209	1	0.4	211	7	3.3	1,888	70	3.7
Trinity	August 9–30	1,554	20	1.2	169	21	12.4	949	4	0.4	269	28	10.3	2,941	73	2.4
Dallas	August 17–October 6.	75	0	0.0	150	7	4.6	74	0	0.0	1,068	64	5.9	1,367	71	5.1
Terrell	September 19	53	0	0.0	....	....	....	46	0	0.0	....	....	....	99	0	0.0
Mineola	August 10–October 2.	445	9	2.0	....	....	....	57	1	1.8	....	....	....	502	10	2.0
Overton	August 23	197	2	1.0	45	1	2.2	37	0	0.0	89	4	4.5	368	7	1.9
Marshall	August 22	23	0	0.0	6	1	16.6	18	0	0.0	52	7	13.5	99	8	8.0
INDIAN TERRITORY.																
Fort Towson	September 12	....	....	....	521	0	0.0	....	....	....	....	....	....	521	0	0.0
Kosoma	September 14	....	....	....	64	0	0.0	....	....	....	....	....	....	64	0	0.0
LOUISIANA.																
Mansfield	August 24–September 29.	491	3	0.6	249	7	2.9	211	0	0.0	626	37	5.9	1,577	47	2.9
Many	August 23	1,315	6	0.4	633	66	10.4	321	5	1.5	539	32	5.9	2,808	109	3.8
Orange	September 23–30	435	5	1.1	....	....	....	67	0	0.0	....	....	....	502	5	0.9
Minden	September 8	....	....	....	218	1	0.5	....	....	....	....	....	....	218	1	0.5
Johnsons Bayou.	August 22	225	0	0.0	....	....	....	....	....	....	....	....	....	225	0	0.0
Total		24,806	796	3.2	5,123	541	10.5	4,307	44	1.02	4,947	308	6.2	39,183	1,689	4.3

The records from only five points extend into three months, and these may be taken as indicative of the seasonal variation at a given locality.

TABLE V.—*Parasitism of the boll weevil in fallen squares, Brownsville, Tex.*

Date.	Stages.	Parasites.	Percentage parasitized.
1906.			
July 28	1,568	50	3.2
August 3	115	2	1.7
September 5	1,147	142	12.4
September 29	265	8	3.0

TABLE VI.—*Parasitism of the boll weevil in fallen squares, Beeville, Tex.*

Date.	Stages.	Parasites.	Percentage parasitized.
1906.			
July 12	656	26	4.0
August 8	442	2	.45
August 13	884	2	.22
September 3	678	6	.9

TABLE VII.—*Parasitism of the boll weevil in fallen squares, Victoria, Tex.*

Date.	Stages.	Parasites.	Percentage parasitized.
1906.			
June 16	864	15	1.8
June 23	667	9	1.3
June 25	396	11	3.0
June 26	652	26	3.9
June 27	829	33	4.0
June 28	423	24	5.7
July 5	535	19	3.5
July 9	560	13	2.3
July 20	518	32	6.1
July 22	87	5	5.7
September 1	1,026	16	1.6

TABLE VIII.—*Parasitism of the boll weevil in all forms, Waco, Tex.*

Date.	Fallen squares.			Hanging squares.			Fallen bolls.			Hanging bolls.		
	Stages.	Parasites.	Per cent of parasitism.	Stages.	Parasites.	Per cent of parasitism.	Stages.	Parasites.	Per cent of parasitism.	Stages.	Parasites.	Per cent of parasitism.
1906.												
July 25	259	26	10.0	99	52	52.6	44	0	0.0	22	0	0.0
August 17	32	2	6.2	22	3	13.6	24	0	0.0	16	0	0.0
August 28	1,217	100	8.2	230	45	19.5	215	5	2.3	405	47	11.6
September 20	......	......	......	109	26	23.8	......	......	......	303	36	11.8

TABLE IX.—*Parasitism of the boll weevil in hanging forms, Dallas, Tex.*

Date.	Hanging squares.			Hanging bolls.		
	Stages.	Parasites.	Per cent of parasitism.	Stages.	Parasites.	Per cent of parasitism.
1906.						
August 29	12	1	8.5	26	0	0.0
September 12	118	6	5.0	182	15	8.2
October 2	8	0	0.0	250	10	4.0
October 6	12	0	0.0	610	39	6.3

The only one of these tables in which there appears any definite progression is the Victoria table, in which there is a regular increase of percentage throughout the last half of June.

FIELD CONDITIONS.

In order to arrive at an explanation for the obviously irregular conditions of parasitism, the figures have also been rearranged according to field conditions. It was found that generally hanging forms in wooded or cleared country were more highly parasitized than those on prairie land. The only definite comparisons which could be found were as follows:

TABLE X.—*Percentage of parasitism of the boll weevil in forms in woodland and on prairie.*

Locality.	Date.	Woodland.		Prairie.	
		Hanging forms.	Fallen forms.	Hanging forms.	Fallen forms.
	1906.				
Goliad	September 3	11.2	8.2	6.0	6.4
Waco	September 19	14.9		14.6	

Stages in fallen forms on prairie land were found to have a higher general percentage of parasitism than those in woodland, although the definite case of Goliad gives a different condition. It is only necessary to quote the highest percentages reached in each condition to give support to these statements.

The highest percentage in hanging forms on woodland was 42.6.

The highest percentage in fallen forms on woodland was 8.3.

The highest percentage in hanging forms on prairie was 14.6.

The highest percentage in fallen forms on prairie was 10.1.

Considerable contradictory matter was brought out in comparing the parasitism in fallen forms in shade and in those exposed to the sun. The weight of evidence supports the statement that those fallen and exposed to sunlight are more highly parasitized than those which fall on moist shaded soil. Only five definite comparisons can be presented to show the irregularities which exist.

TABLE XI.—*Parasitism of the boll weevil in fallen forms in sun and shade.*

Locality.	Date.	Woodland.		Prairie.	
		Shade.	Sun.	Shade.	Sun.
	1906.				
Mansfield, La	August 24	0.54	1.09		
Taylor, Tex	August 16			0.69	1.3
Trinity, Tex	August 8	2.3	1.07		
Victoria, Tex	July 20				6.5
Victoria, Tex	July 22			2.6	
Waco, Tex	August 29	8.7	6.8		

The highest percentages obtained in each class are as follows:

In shade on woodland	8.7
In sun on woodland	8.3
In shade of plants on prairie	8.2
In sun on prairie	10.1

Should further inquiry prove that sun-dried squares are the most highly parasitized, another reason is presented for wide rows.

GEOGRAPHICAL CONSIDERATIONS.

By far the most important facts established by the table of percentage of parasitism (Table IV) were elicited by using the geographical map of Texas, published in the census of 1880, as a base.

I. The alluvial prairie of the Rio Grande is represented by Brownsville with an average percentage of parasitism in all forms of 6.1.

II. The coast prairie is represented by Corpus Christi with 8.5 per cent, Goliad with 8.0 per cent, Cuero with 5.5 per cent, and Victoria with 3.7 per cent.

III. The Edwards plateau is represented by Junction with 8.2 per cent, Roosevelt with 6.9 per cent, and 16 miles south of Roosevelt with 2.2 per cent. This latter case was a farm with very rank growth of cotton, from which shaded squares were picked on the ground. The weevil had not been present long.

IV. The black prairie is represented by Kerrville with 3.3 per cent, Taylor with 2.6 per cent, Corsicana (IVb) with 6.0 per cent, and Dallas with 5.1 per cent.

V. The cross timbers are represented by Waco with 11.4 per cent.

VI. The eastern hardwoods are represented on the south by Beeville with 1.2 per cent, Hallettsville with 2.8 per cent, each at the tip of an extension of this region, and by Calvert with 2.1 per cent, Palestine 3.7 per cent, Mineola 2.0 per cent, Overton 1.9 per cent, Marshall 8.0 per cent, Mansfield, La., 2.9 per cent, Many, La., 3.8 per cent. Marshall is probably represented by a field on a red-land knoll, which would account for the discrepancy.

VII. The eastern pine country is represented by Trinity with 2.4 per cent, and Orange, La., with 0.9 per cent. Trinity is in a transitional region of pines and hardwoods, but seems to belong more typically to the hardwood region.

It will be readily observed that regions I, II, III, V, with Corsicana in IVb, which really belongs to the brown loam region in the eastern hardwoods, and Marshall in VI, which belongs to the red-land areas of the eastern hardwoods, are the most highly parasitized, while the regions IV, VI, and VII are the lowest parasitized.

The map on the opposite page (fig. 4) is presented to illustrate these statements.

While it may be merely a coincidence that the places in the same belt have about the same proportion of parasitism, it is nevertheless worthy of some attention. It is undoubtedly true that each of these floral regions is also a distinct subfaunal region. It may therefore be expected that different weevils will exist in the different belts and different parasites operate upon these weevils. Some of these parasites may be able more readily than others to adopt the boll weevil as a host, or in certain regions there may be more species of parasites capable of doing this. In the discussion of the geographical distribution of the parasites more light will be thrown upon this question.

FIG. 4. Map of Texas, divided into geographical regions and illustrating average percentage of parasitism of the boll weevil in all cotton forms: I, alluvial prairie; II, coast prairie; III, Edwards Plateau; IV, black prairie; IV^b, brown loam prairie; V, cross timbers; VI, oak, hickory, and pine; VII, pines. (Original.)

BOLL WEEVIL STATUS.

That there should be some definite relation between the percentage of infestation and the percentage of parasitism was expected, on the ground that a condition favorable to the weevil should be favorable to the parasites. It was, of course, conceded that climate would be another agency to figure in the question. The year's work is deficient in that coordinate examinations of infestations and parasitism were not taken. In another year this will be necessary in order to show whether the parasites are reducing the infestation.

At present no relation can be found between parasitism and infestation or climatology. Beeville, Goliad, and Victoria have a mean annual temperature of 70° and a precipitation of 30 inches. At Beeville the average percentage of parasitism in fallen squares was 1.3 per cent, at Goliad 8.5 per cent, at Victoria 3 per cent. This condition occurs throughout the entire State. At Calvert the percentage of infestation of squares on August 28 was 55.6 per cent and at Goliad it was 20.9 per cent, and yet the average percentage of parasitism in fallen squares at Calvert was 1.4 per cent and Goliad 8.5 per cent. A reverse condition may be cited as follows: At Cuero the percentage of infestation of squares on August 28 was 74 per cent and at Victoria it was 32.7 per cent, and the average percentage of parasitism in hanging squares at Cuero was 19.9 per cent and at Victoria 10.2 per cent. Table XII gives in detail the irregularity displayed between these three factors.

TABLE XII.—*Boll weevil status and parasitism.*

Locality.	Mean annual temperature.	Mean annual precipitation.	First examination, July 3, 1906.		Weevil status, Aug. 28, 1906.		Average parasitism, 1906.			
			Average per acre.		Percentage infested.		Squares.		Bolls.	
			Plants.	Weevils.	Squares.	Bolls.	Fallen.	Hanging.	Fallen.	Hanging.
Brownsville, Tex	72	25	......	......	......	......	6.5	......	3.3	......
Corpus Christi, Tex	70	30	9,412	212	71.0	84.0	9.0	......	0.0	......
Beeville, Tex	70	30	8,859	300	21.8	3.1	1.3	......	0.0	......
Goliad, Tex	70	30	10,169	305	20.9	1.6	8.5	13.8	2.2	4.9
Victoria, Tex	70	30	8,334	119	32.7	15.0	3.0	10.2	0.0	.5
San Antonio, Tex	68	25	12,186	101	38.0	.2	0.0	......	......	......
Yorktown, Tex	68	30	......	......	67.2	20.5	......	......	......	......
Cuero, Tex	68	30	7,225	135	74.0	59.0	1.0	19.9	0.0	1.0
Hallettsville, Tex	68	30	8,056	289	78.0	3.2	.4	9.2	1.0	3.7
Austin, Tex	68	30	15,580	73	19.2	.27	......	......	......	......
Giddings, Tex	68	30	15,600	76	34.5	2.1	......	......	......	......
Lula, Tex	66	25	......	......	......	......	0.0	......	......	......
Sixteen miles south of Roosevelt, Tex	66	25	......	......	......	......	2.4	......	......	......
Roosevelt, Tex	66	25	......	......	......	......	14.4	......	0.0	......
Junction, Tex	66	25	......	......	......	......	8.2	......	5.8	......
Mountain Home, Tex	66	25	......	......	......	......	0.0	......	......	......
Kerrville, Tex	66	25	......	......	......	......	10.5	......	2.3	......
Bryan, Tex	68	40	10,170	38	52.3	4.1	......	......	......	......
Hempstead, Tex	68	40	12,255	84	74.7	10.5	......	......	......	......
Eagle Lake, Tex	68	40	5,735	89	20.8	13.0	......	......	......	......
Wharton, Tex	68	40	5,127	93	54.0	17.3	......	......	......	......
Taylor, Tex	66	30	......	......	......	......	.6	5.0	1.5	2.5
Cameron, Tex	66	30	16,317	67	73.3	46.0	......	......	......	......
Waco, Tex	66	30	13,800	49	68.7	6.2	8.4	27.3	1.7	11.1
Hillsboro, Tex	66	30	18,200	0	4.8	3.4	......	......	......	......
Corsicana, Tex	66	30	20,524	0	38.0	1.4	0.0	11.7	5.9	3.4
Mexia, Tex	66	30	18,520	0	.8	0.0	......	......	......	......
Calvert, Tex	66	40	11,377	196	55.6	8.0	1.4	9.8	0.0	6.6
Palestine, Tex	66	40	12,712	61	52.8	14.4	1.2	11.5	.4	3.3
Athens, Tex	66	40	11,568	21	21.6	1.7	......	......	......	......
Troupe, Tex	66	40	8,126	390	92.0	67.5	......	......	......	......
Jacksonville, Tex	66	40	10,963	160	70.0	32.0	......	......	......	......
Henderson, Tex	66	40	7,536	564	87.6	52.8	......	......	......	......
Dallas, Tex	64	40	......	......	22.5	0.0	0.0	4.6	0.0	5.9
Terrell, Tex	64	40	14,000	0	0.0	0.0	0.0	......	0.0	......
Mineola, Tex	64	40	1,607	105	......	......	2.0	......	1.8	......
Marshall, Tex	66	50	9,480	69	78.0	29.0	0.0	16.6	0.0	13.5
Trinity, Tex	68	50	9,990	182	50.8	11.0	1.2	12.4	.4	10.3
Lufkin, Tex	68	50	11.320	36	53.2	10.7	......	......	......	......
Overton, Tex	68	50	7,780	69	78.0	29.0	1.0	2.2	0.0	4.5
Fort Towson, Ind. T	64	50	......	0	0.0	0.0	......	0.0	......	0.0
Kosoma, Ind. T	64	50	......	0	0.0	0.0	......	0.0	......	0.0
Mansfield, La	68	50	......	......	......	......	.6	2.9	0.0	5.9
Many, La	68	50	......	......	......	......	.4	10.4	1.5	5.9
Orange, La	68	50	......	......	......	......	1.1	......	0.0	......
Minden, La	66	50	......	0	0.0	0.0	......	.5	......	......
Johnsons Bayou, La	70	50	......	......	......	......	0.0	......	......	......

BOLL WEEVIL CHRONOLOGY.

The boll weevil has been present in the United States since 1892. Year by year it has extended its ravages, although during the summer of 1896 and the winter of 1904–5 it received severe setbacks. Its territory now extends into four States, and in three of these observations as to parasitism were made. Several examinations were made immediately after the dispersion of August in newly infested fields, and at Minden, La., it was actually found that parasitization had commenced within two weeks of the weevil's arrival. The parasites do not follow the weevil; they are already present and native to the country invaded. Thus it is that in some parts of Texas where the weevil has been present ten or more years the parasites have not as great a hold as they have at Waco, which has only had it four years. There are probably more sources for parasites at Waco than at other points.

TABLE XIII.—*Weevil chronology and parasitism.*

Locality.	Chronology.	Average parasitism.			
		Squares.		Bolls.	
		Fallen.	Hanging.	Fallen.	Hanging.
Minden, La	Weevil arrived in the August dispersion of 1906. First generation in green squares collected.	....	.5	....	....
Fort Towson, Ind. T	.....do	....	0.0	....	....
Kosoma, Ind. T	.....do	....	0.0	....	....
Lula, Tex	Weevil arrived in 1906, probably	0.0	....	....	....
Sixteen miles south of Roosevelt, Tex.	Weevil arrived in 1905 or 1906	2.4	....	....	....
Roosevelt, Tex	Weevil arrived in 1905	14.4	....	0.0	....
Junction, Tex	.....do	8.2	....	5.8	....
Mountain Home, Tex	.....do	0.0	....	....	....
Kerrville, Tex	Weevil arrived in 1904 or 1905	10.5	....	2.3	....
Dallas, Tex	Weevil arrived in 1904; set back February, 1905; rearrived 1905.	0.0	4.6	0.0	5.9
Mineola, Tex	.....do	2.0	....	1.8	....
Terrell, Tex	.....do	0.0	....	0.0	....
Johnsons Bayou, La	Weevil arrived in the August dispersion of 1904.	0.0	....	....	....
Mansfield, La	.....do	.6	2.9	0.0	5.9
Marshall, Tex	.....do	0.0	16.6	0.0	13.5
Overton, Tex	.....do	1.0	2.2	0.0	4.5
Many, La	Weevil arrived in the fall of 1903	.4	10.4	1.5	5.9
Corsicana, Tex	Weevil present in 1903	0.0	11.7	5.9	3.4
Waco, Tex	Weevil present in 1902	8.4	27.3	1.7	11.1
Trinity, Tex	Weevil present in 1901	1.2	12.4	.4	10.3
Palestine, Tex	.....do	1.2	11.5	.4	3.3
Calvert, Tex	.....do	1.4	9.8	0.0	6.6
Taylor, Tex	.....do	.6	5.0	1.5	2.5
Hallettsville, Tex	Weevil present in 1897	.4	9.2	1.0	3.7
San Antonio, Tex	Weevil arrived in 1894; set back until 1897.	0.0	....	....	....
Cuero, Tex	Weevil arrived in 1895; set back until 1896.	1.0	19.9	0.0	1.0
Victoria, Tex	.....do	3.0	10.2	0.0	.5
Goliad, Tex	Weevil present in 1894	8.5	13.8	2.2	4.9
Corpus Christi, Tex	Weevil present in 1893	9.0	....	0.0	....
Beeville, Tex	.....do	1.3	....	0.0	....
Brownsville, Tex	Weevil present in 1892	6.5	....	3.3	....

CONCLUSIONS.

A few points of practical importance have been deduced from the foregoing general tables.

1. Inasmuch as the parasites are known to attack the weevil in its first generation in a newly infested locality, it may be expected that by releasing the proper parasites in a given locality the percentage of parasitism may be increased in a very short time. Such a case was actually obtained by the release of *Bracon mellitor* at Dallas, as described in the section on propagation.

2. Dryness and sunlight assist attack by the chalcidoid and braconid parasites of the weevil, as proved by the following considerations: (It is, of course, to be understood that this conclusion may hold only for those species and regions studied. In fact two or three of the minor species, such as the tachinids, give promise of doing most favorable work under directly opposite conditions in regions so far unstudied.)

a. Stages in hanging forms are, as a rule, parasitized to a higher degree than those in fallen forms.

b. Stages in fallen forms on prairie land are generally more highly parasitized than those in wooded country, although frequently hanging forms in wooded country are more highly parasitized than those in prairie land.

c. Fallen and hanging forms on unshaded ground are more highly parasitized than those on shaded soil.

These facts give an added importance to certain cultural methods already advocated, viz:

a. That the rows should be far apart, in order to allow the sun to dry the squares on the ground.

b. That determinate varieties should be planted in order to give additional heat and light for the parasites during the cooler autumn months.

That, as indicated by the present studies, dryness seems to be a most favorable condition for attack by hymenopterous parasites is quite natural, as these delicate little insects are very fond of sunlight and warmth.

II. Propagation Work.

1. INTERIOR WORK — TRANSFER OR ARTIFICIAL PROPAGATION OF PARASITES.

It has not been a difficult matter to breed the parasites of the boll weevil. There have been used in this laboratory four distinct methods of obtaining parasites, all of which served the purpose for which they were used. In all cases where definite records of percentage, length of stages, or nature of parasitism were required there has been a careful examination of each form (square or boll), and those forms containing parasites, or sometimes only the parasite and its host, were placed in individual pill bottles, numbered, recorded, and placed in trays for daily observation. A somewhat less exact method has been to place a limited number of squares in a tumbler on moist or dry soil in order to make the time of development more nearly normal. These tumblers were covered with cheese cloth and tagged.

When definite records were not requisite large quantities of squares or bolls were placed in Riley breeding cages and the parasites were obtained in larger quantities with less mortality, which is frequently caused by rough handling in the closer examinations. Closed boxes with numerous tubes on one side, after the pattern of the parasite breeding cages adopted by the California board of horticulture, were also used for small quantities of squares. These cages probably hasten development by increasing the heat and moisture.

There was, however, another problem which proved beyond solution for this season. It may be described as the effort to induce the parasites to attack the stages in forms placed in cages of various kinds. No positive results were obtained, but considerable experience was gained in the matter of breeding-cage technique.

The first work was done with various kinds of glassware, closed with cheese cloth. As fast as males and females of the same species could be bred they were isolated in pairs and placed with a limited number of infested squares. These squares were fresh, flared, or fallen, in order to test all conditions.

Glass tumblers covered with cheese cloth proved too dark. When dry earth was placed in the tumbler or when there was no earth, the squares rapidly dried and became very hard, and the parasites quickly died. When moistened earth was used the squares quickly molded and the parasites were killed by the fungus. When a water reservoir was sunk in the earth the parasites drowned.

When glass lamp chimneys were placed on clay saucers filled with moist soil there was plenty of light and the material remained in good condition. The objection to this method is that the parasites can not be easily handled.

Erlenmyer flasks gave plenty of light and were easy to handle as they have a small mouth, but they sweat profusely and the parasites were caught in the moisture on the glass. Blotters, absorbent cotton, and corks with large wire-covered openings failed to prevent the sweating.

The last attempt on this line was with mica lamp chimneys such as are used with the ordinary incandescent gas burners. These were covered at both ends with cheese cloth. They are of light weight, give plenty of sunshine and sufficient circulation. For a small breeding cage they are very handy in many ways. But the parasites did not attack the weevil even in these cages.

In all of the above types of cages the life of the parasite was hardly a day. In wire types of cages the parasites lived several days. In the following, several of each sex of the parasites were used.

The first type was a cubic cage made very easily by using strips of cork for the framework and fine meshed wire (known as 50 to the inch, but really 35 and 45 to the inch) for the sides. One side was fixed with two openings which were closed on the inside by a tin shutter. The lower opening was round, and in this a cork with a glass tube through it was placed before the shutter was raised. Thus the parasites, being attracted to light, could be quickly removed by darkening the sides and allowing the light to enter only through the tube. When the shutter was raised higher it exposed a larger opening through which material could be passed.

With this first cage as a type various modifications were contrived, all with wire fronts, shutters of various kinds, and corked holes for the admission of a tube or for passing in small objects. Cigar boxes became the bases for these cages.

Still another modification was a wire cylinder corked at one end and with a smaller cork centered in this for the removal of material. The other end was covered with cheese cloth.

It was found impossible to provide plant conditions in a small cage unless the plant were actually transplanted or grown from seed. A branch of cotton withers so quickly that experiments of this sort were of no value.

Both kinds of tubes were tested on the plants, but the mica tube caused a heavy sweat and killed the branch it was on; the wire tube was too heavy. All of the plants placed under the large parasite-tight cages with glass sides died before results could be expected.

2. FIELD WORK—RELEASE OF PARASITES.

The release of parasites in the field was not commenced until September 12 on account of the small amount of material gathered prior to that date. Notwithstanding that fact the results give an indication of success. On the laboratory farm at the top of the hill there were released 35 parasites on September 12 and 38 on September 15. These parasites were of three species. An examination of hanging forms was made in this part of the field and another down the hill at the opposite side and about 350 yards distant. At this time the check area ("B," fig. 5) showed 1.9 per cent higher parasitism than the parasite area ("A," fig. 5). Twenty days later, on October 2, like examinations were made with the result that the percentages were reversed; "A" showed an increase of 2.6 per cent and "B" showed a decrease of 6.5 per cent; that is, "A" was 7.2 per cent more highly parasitized than "B" and showed a real gain in parasitism of 9.1 per cent. On October 6 this examination was followed by another, and, although the difference was less, "A" was 3.9 per cent more highly parasitized than "B." Plat "A" was next to a fence and separated from another field of cotton by a road and a high hedge of *Ambrosia trifida* with scattered *Solanum rostratum.* As a further check on the experiment the nearest part of this field ("D," fig. 5) was examined and proved to be parasitized by 2.1 per cent less than "A." On the contrary, the farther part of the field ("E," fig. 5) showed 5.8 per cent higher parasitism than "A." The conclusion was that "E" and "D" did not influence "A."

The results are given in Table XIV for the entire experiment, and also according to species. It is believed by the writer that it was the release of *Bracon mellitor* which accomplished the change.

The evidence upon which this belief is founded is both positive and negative. *Bracon mellitor* was not found breeding upon any other species of weevil in the vicinity, and yet the examinations showed an increase of parasitization by this species in the "parasite

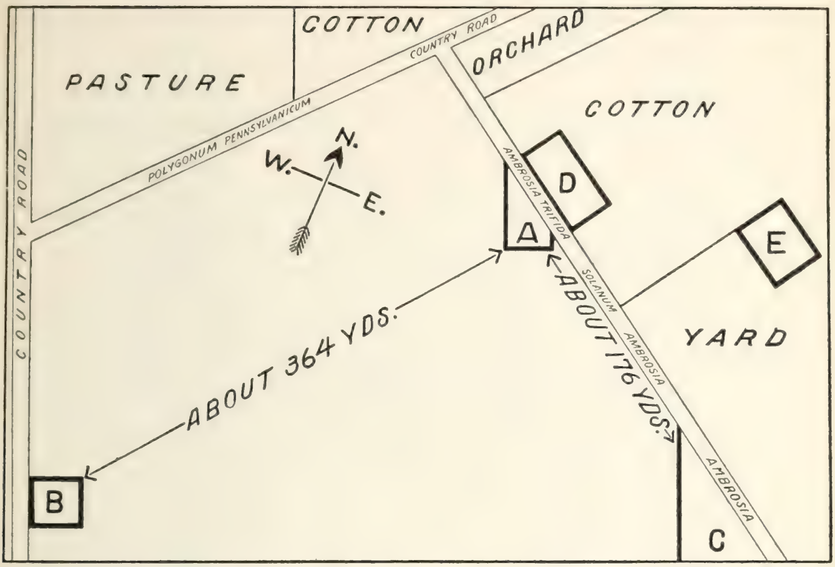


FIG. 5.—Diagram of cotton plantation of H. O. Samuel, Dallas, Tex., of 64.4 acres, showing location of plats where observations and experiments on boll-weevil parasitism were made. (Original.)

area" opposed to a decrease in the "check area." *Catolaccus incertus,* although released in large numbers, did not take hold at all, nor was it found breeding upon any other species of weevil in the vicinity. A few *Cerambycobius cyaniceps* were released, but the only trace of parasitization by this species was found in the original check. And yet this species was bred from *Lixus musculus* in the stems of *Polygonum pennsylvanicum* near by, and also from *Trichobaris texana* Lec., in the stems of *Solanum rostratum* adjacent to "A". No *Eurytoma tylodermatis* were released, although this species was abundant throughout the field. It is known as a parasite of *Lixus scrobicollis* Boh., which breeds in *Ambrosia trifida* stems. Immense numbers of this plant were growing along the road adjacent to "A." In order to show that plat "E," which was highly parasitized by

Bracon mellitor, did not influence the numbers of that species in "A," the fact may be cited that the higher percentage of *Eurytoma tylodermatis* in "E" evidently had no influence upon the presence of that species in "A."

TABLE XIV.—*Release of parasites of the boll weevil—Summary of all species.*

Date.	"A." Parasite area.			"B." Check area.			"C." Check area.			"D." Area across road.			"E." Area 100 yards from "D."			Total.		
	Stages of the weevil.	Number of stages parasitized.	Percentage parasitized.	Stages of the weevil.	Number of stages parasitized.	Percentage parasitized.	Stages of the weevil.	Number of stages parasitized.	Percentage parasitized.	Stages of the weevil.	Number of stages parasitized.	Percentage parasitized.	Stages of the weevil.	Number of stages parasitized.	Percentage parasitized.	Stages of the weevil.	Number of stages parasitized.	Percentage parasitized.
Sept. 12	120	7	5.8	180	14	7.7										300	21	7.0
	Released 27 ♀, 8 ♂.																	
Sept. 15	Released 35 ♀, 3 ♂.																	
Oct. 2	95	8	8.4	163	2	1.2										258	10	3.8
Oct. 6	183	13	7.1	125	4	3.2				218	11	5.0	96	11	12.9	622	39	6.2
Oct. 10							247	5	2.02							247	5	2.0

TABLE XV.—*Release and parasitism of Bracon mellitor.*

Date.	"A." Parasite area.			"B." Check area.			"C." Check area.			"D." Area across road.			"E." Area 100 yards from "D."			Total.		
	Stages of the weevil.	Number of stages parasitized.	Percentage parasitized.	Stages of the weevil.	Number of stages parasitized.	Percentage parasitized.	Stages of the weevil.	Number of stages parasitized.	Percentage parasitized.	Stages of the weevil.	Number of stages parasitized.	Percentage parasitized.	Stages of the weevil.	Number of stages parasitized.	Percentage parasitized.	Stages of the weevil.	Number of stages parasitized.	Percentage parasitized.
Sept. 12	120	2	1.66	180	4	2.22										300	6	2.0
	Released 14 ♀, 6 ♂.																	
Oct. 2	95	5	5.26	163	1	.61										258	6	2.3
Oct. 6	183	6	3.27	125	1	.80				218	7	3.22	96	5	5.21	622	19	3.0
Oct. 10							247	5	2.02							247	5	2.0

TABLE XVI.—*Release and parasitism of Catolaccus incertus.*

Date.	"A." Parasite area.			"B." Check area.			"C." Check area.			"D." Area across road.			"E." Area 100 yards from "D."			Total.		
	Stages of the weevil.	Number of stages parasitized.	Percentage parasitized.	Stages of the weevil.	Number of stages parasitized.	Percentage parasitized.	Stages of the weevil.	Number of stages parasitized.	Percentage parasitized.	Stages of the weevil.	Number of stages parasitized.	Percentage parasitized.	Stages of the weevil.	Number of stages parasitized.	Percentage parasitized.	Stages of the weevil.	Number of stages parasitized.	Percentage parasitized.
Sept. 12	120	0	0.0	180	4	2.22										300	4	1.3
	Released 10 ♀, 2 ♂.																	
Sept. 15	Released 30 ♀, 1 ♂.																	
Oct. 2	95	0	0.0	163	0	0.0										258	0	0.0
Oct. 6	183	1	.54	125	0	.0				218	0	0.0	96	0	0.0	622	1	0.1
Oct. 10							247	0	0.0							247	0	0.0

TABLE XVII.—*Release and parasitism of Cerambycobius cyaniceps.*

Date.	"A." Parasite area.			"B." Check area.			"C." Check area.			"D." Area across road.			"E." Area 100 yards from "D."			Total.		
	Stages of the weevil.	Number of stages parasitized.	Percentage parasitized.	Stages of the weevil.	Number of stages parasitized.	Percentage parasitized.	Stages of the weevil.	Number of stages parasitized.	Percentage parasitized.	Stages of the weevil.	Number of stages parasitized.	Percentage parasitized.	Stages of the weevil.	Number of stages parasitized.	Percentage parasitized.	Stages of the weevil.	Number of stages parasitized.	Percentage parasitized.
Sept. 12......	120	0	0.0	180	1	0.55	....	....	....	....	....	....	....	....	....	300	1	0.3
	Released 3 ♀.																	
Sept. 15......	Released 5 ♀, 1 ♂.																	
Oct. 2........	95	0	.0	163	0	0.0	....	....	....	....	....	....	....	....	....	258	0	0.0
Oct 6........	183	0	.0	125	0	.0	....	....	....	218	0	0.0	96	0	0.0	622	0	0.0
Oct. 10......	....	....	....	....	....	....	247	0	0.0	....	....	....	....	....	....	247	0	0.0

TABLE XVIII.—*Parasitism of Eurytoma tylodermatis.*

Date.	"A." Parasite area.			"B." Check area.			"C." Check area.			"D." Area across road.			"E." Area 100 yards from "D."			Total.		
	Stages of the weevil.	Number of stages parasitized.	Percentage parasitized.	Stages of the weevil.	Number of stages parasitized.	Percentage parasitized.	Stages of the weevil.	Number of stages parasitized.	Percentage parasitized.	Stages of the weevil.	Number of stages parasitized.	Percentage parasitized.	Stages of the weevil.	Number of stages parasitized.	Percentage parasitized.	Stages of the weevil.	Number of stages parasitized.	Percentage parasitized.
Sept. 12.....	120	0	0.0	180	3	1.66	....	....	....	....	....	....	....	....	....	300	3	1.0
Oct. 2........	95	2	2.10	163	0	.0	....	....	....	....	....	....	....	....	....	258	2	0.7
Oct. 6........	183	1	.54	125	1	.80	....	....	....	218	2	0.91	96	6	6.25	622	10	1.6
Oct. 10......	....	....	....	....	....	....	247	0	0.0	....	....	....	....	....	....	247	0	0.0

III. PARASITE BREEDING WORK.

Four new primary parasites of the boll weevil have been bred this year, and several definite cases of predaceous attack have been observed. There are now known 11 primary hymenopterous parasites, 1 primary dipterous parasite, 2 acarid parasites (at least), 2 coleopterous enemies, and 2 ant enemies which attack the weevil stages in the cotton forms. They are as follows (insects which attack the adult weevils are omitted from the consideration):

PRIMARY PARASITES.

Hymenoptera.

Chalcidoidea.

Torymidæ, Monodontomerinæ.

1. *Microdontomerus anthonomi* Cwfd. (Texas).

Eurytomidæ.

2. *Eurytoma tylodermatis* Ashm. (Mexico, Texas, Louisiana).
3. *Bruchophagus herreræ* Ashm. (Mexico).

Encyrtidæ, Eupelminæ.

4. *Cerambycobius cyaniceps* Ashm. (Louisiana, Texas).

Pteromalidæ, Pteromalinæ.

5. *Catolaccus incertus* Ashm. (Texas, Louisiana).

Hymenoptera—Continued.
  Ichneumonoidea.
    Braconidæ, Sigalphinæ.
      6. *Sigalphus curculionis* Fitch (Texas).
      7. *Urosigalphus anthonomi* Cwfd. (Texas, probably Mexico).
      8. *Urosigalphus schwarzi* Cwfd. (Guatemala).
    Braconinæ.
      9. *Bracon mellitor* Say (Mexico, Texas).
      10. *Bracon dorsator* Say (Texas).
      11. Undetermined braconid (Texas).
Diptera.
    Tachinidæ.
      12. *Myiophasia æenea* Wied. (Texas, Louisiana).
Acarina.
      13. *Pediculoides ventricosus* Newp. (Mexico).
      14. *Tyroglyphus breviceps* Banks (Texas).

PREDACEOUS ENEMIES.

Coleoptera.
    Cleridæ.
      15. *Hydnocera pubescens* Lec. (Texas, Louisiana).
    Cucujidæ.
      16. *Cathartus cassiæ* Reiche (Texas).
Hymenoptera.
  Formicoidea.
    Myrmicidæ, Myrmicinæ.
      17. *Solenopsis geminata* Fab. (Guatemala, Texas, Louisiana).
    Formicidæ, Formicinæ.
      18. *Formica fusca subpolita perpilosa* (Mexico).

HYPERPARASITES.

Hymenoptera.
      Microdontomerus anthonomi Cwfd.
      Eurytoma tylodermatis Ashm.
      Cerambycobius cyaniceps Ashm.
      } Accidental on *Bracon mellitor* Say.

POSSIBLE PRIMARY PARASITES.

Hymenoptera.
      Catolaccus anthonomi Ashm. (Texas).

Two species of entomogenous fungi, *Aspergillus* sp. and *Cordyceps* sp., have been recorded as probably parasites of boll-weevil larvæ.

OCCURRENCE OF SPECIES.

1. *Microdontomerus anthonomi* Cwfd.[a] This species was collected as follows: Goliad, Tex., September 3, 1906, 1 bred from *Bracon mellitor* cocoon; Cuero, Tex., August 31, 1906, 1 bred from *Bracon mellitor* cocoon; Hallettsville, Tex., August 30, 1906, 4 females, primary parasites upon *A. grandis;* Waco, Tex., August 28, 1906, 2 females, primary parasites upon *A. grandis;* Waco, Tex., August 29, 1906, 1 male, 3 females, primary parasites upon *A. grandis:* Waco, Tex. August 29, 1906, 1 male, bred from *Bracon mellitor* cocoon.

[a] Crawford, 1907a, b.

The range of the Microdontomerus is evidently western. Twenty-three per cent were secondary parasites.

2. *Eurytoma tylodermatis* Ashm. This species, while not very important in any part of the State, is very well distributed. It was recorded continuously after July 12, 1906. Specimens were bred from material collected at Beeville, Brownsville, Calvert, Cuero, Dallas, Goliad, Hallettsville, Overton, Palestine, Trinity, Victoria, and Waco, Tex., and at Mansfield and Many, La. No records were obtained from Corpus Christi, Corsicana, Junction, Kerrville, Lula, Marshall, Mineola, and Taylor, Tex.; nor from Orange, La. Specimens were sent in by Prof. A. L. Herrera from Allende, Coahuila, Mexico, with the note that it was abundant at that place.

3. *Bruchophagus herreræ* Ashm. This parasite has not been taken in the United States. It was described from Coahuila, Mexico.

4. *Cerambycobius cyaniceps* Ashm. This parasite has been taken at all points investigated except those in the Edwards Plateau region.

5. *Catolaccus incertus* Ashm. This parasite has not been taken at Overton or Marshall in northeastern Texas, but is common at all other points investigated.

6. *Sigalphus curculionis* Fitch has not been recorded since the first specimen was bred at Calvert, Tex.

7. *Urosigalphus anthonomi* Cwfd.[a] One female was bred from a cocoon in a weevil cell from material collected September 5 at Brownsville, Tex. As the former record was also from Brownsville, this species may be taken to be Mexican in origin.

8. *Urosigalphus schwarzi* Cwfd.[a] From 300 squares Mr. E. A. Schwarz and Mr. H. S. Barber bred 5 females and 1 male of this newly described species at Cacao, Finca Trece Aguas, Alta Vera Paz, Guatemala, during April, 1906.

9. *Bracon mellitor* Say was bred from all points, except Overton and Marshall in northeastern Texas. The form known as *Bracon xanthostigma* has only been bred from the weevil between September 16 and April 28 in the various years of this investigation. A specimen of this species is recorded on the Bureau of Entomology files (D. A. 6424 (412)) as bred from the boll weevil at Coahuila, Mexico, November 15, 1902, by Professor Herrera. Specimens were sent in by Professor Herrera from Allende, Coahuila, Mexico, during 1906, with the notes that they were quite common.

10. *Bracon dorsator* Say was not bred until October in 1906. It is only known to occur between August 2 and December 17 in Texas. It is probably another instance of seasonal dimorphism and identical with *Bracon mellitor*.

11. Braconid. One female of this species was bred September 1 from a cocoon in material collected on the ground at Victoria, Tex. The specimen was lost in transit.

[a] Crawford, 1907a.

12. *Myiophasia ænea* Wied. Pupæ of this species within the larval skin of the weevil were taken from material collected at Many, La. (3 specimens), and Waco, Tex. (1 specimen); also one specimen in imperfect condition was found in a small boll collected at Victoria, Tex., July 12. Its puparium was within the skin of a weevil larva.

13. *Pediculoides ventricosus* Newp. is a common weevil parasite in Mexico.

14. Mites were frequently found to have destroyed the weevil stages in fallen squares, especially at Calvert, Tex.

Tyroglyphus breviceps Banks was described as a weevil enemy from Victoria, Tex.

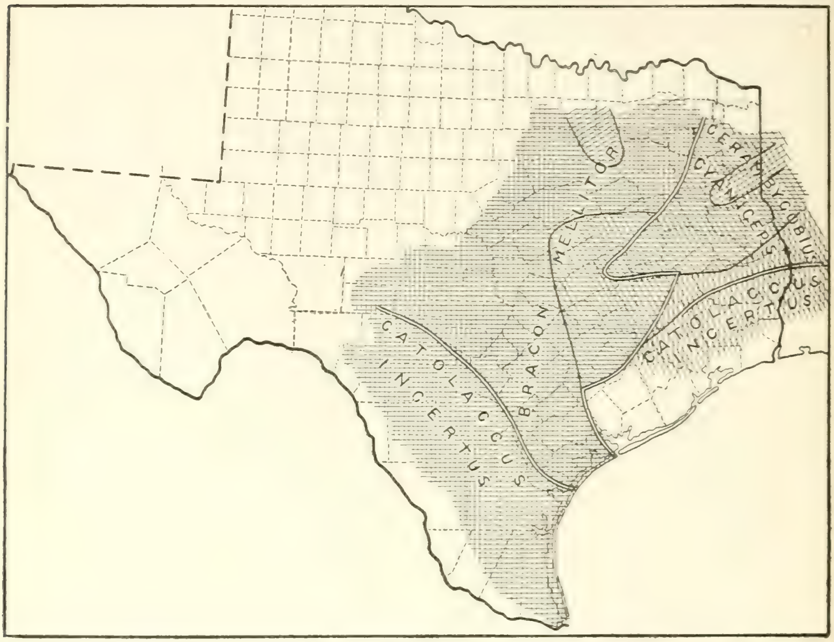


FIG. 6.—Occurrence of predominant parasites of the boll weevil in Texas and western Louisiana showing—
Occurrence of *Catolaccus incertus*. *Bracon mellitor*. *Cerambycobius cyaniceps*. *Eurytoma tylodermatis*. Limits of predominance of single species. Limits of two predominant species. (Original.)

15. *Hydnocera pubescens* Lec. was found frequently to have killed weevil stages. Records of this predatory habit are from Brownsville and Waco, Tex., and Many, La. In a great many other cases evidence of its predatory nature was less reliable.

16. *Cathartus cassiæ* Reiche was found several times to be predaceous in its larval stage upon the weevil.

Catolaccus anthonomi Ashm., determined by J. C. Crawford. Four specimens practically identical in character with the type of this species were bred from cotton squares collected October 12, 1906, at

Waco, Tex. Although a large quantity of these squares were examined, no specimens of this species were obtained except from the general breeding cage. The species is known as a parasite of an æstivating weevil (*Anthonomus signatus* Say), and it is possible that in the fall the parasites may attack *Anthonomus grandis*.

GEOGRAPHICAL AND SEASONAL DISTRIBUTION OF PARASITES.

Only four of these parasites are at present of any great importance. In arranging the percentages of each species with regard to the total number of parasites the following table (Table XIX) has brought out sufficient data for the production of a map (fig. 6) which shows the area over which any two of them are predominant. Thus, over the entire western half of the area studied *Bracon mellitor* and *Catolaccus incertus* are the most active, while in the Northeast and East *Cerambycobius cyaniceps* shares the importance with the other three in more or less limited belts:

TABLE XIX.—*The seasonal distribution of the parasites.*

Locality.	Date.	Total number of parasites.	Bracon mellitor.		Catolaccus incertus.		Eurytoma tylodermatis.		Cerambycobius cyaniceps.	
			Number.	Percentage.	Number.	Percentage.	Number.	Percentage.	Number.	Percentage.
	1906.									
Beeville, Tex.	July 12	26	8	30.7	5	19.2	2	7.6	1	3.8
Do	August 8	2	2	100.0						
Do	August 13	2								
Do	September 3	6	6	100.0						
Brownsville, Tex.	July 5	43	38	88.3	5	11.7				
Do	July 28	119	39	32.7	77	64.7	3	2.6		
Do	August 3	2								
Do	September 5	155	50	32.2	85	54.8	1	0.6	2	1.2
Do	September 29	53	12	22.6	40	75.4				
Calvert, Tex.	August 28	13	3	23.0	3	23.0	1	7.6	4	30.7
Do	September 13	21	3	14.2					4	19.0
Corpus Christi, Tex.	July 10	39	9	23.0	12	30.7	1	2.5		
Corsicana, Tex.	August 23	19	9	47.3	4	21.0	1	5.2		
Do	September 18	2	1	50.0						
Cuero, Tex.	August 9	13	3	23.0	2	15.3			1	7.6
Do	August 31	87	45	51.7	25	28.7	6	6.8	4	4.5
Dallas, Tex.	August 29	1								
Do	September 12	21	6	28.5	4	19.0	3	14.2	1	4.7
Do	October 2	10	6	60.0			2	20.0		
Do	October 6	39	19	48.4	1	2.5	9	23.0		
Do	October 10	5	5	100.0						
Goliad, Tex.	August 7	7								
Do	September 3	108	73	67.5	22	20.3	3	2.7	2	1.8
Hallettsville, Tex.	August 9	15	3	20.0	3	20.0	2	13.3	1	6.6
Do	August 30	39	7	17.9	4	10.2	7	17.9	8	20.4
Junction, Tex.	September 24	12	10	83.3	2	16.7				
Kerrville, Tex.	August 26	6	3	50.0	2	33.3				
Do	September 3	5	2	40.0	1	20.0				
Mansfield, La.	August 24	47	5	10.6	2	4.2	1	2.1	36	76.5
Many, La.	August 23	109	6	5.5	12	11.0	8	7.3	45	41.2
Marshall, Tex.	August 22	8							6	75.0
Mineola, Tex.	August 10	1								
Do	October 2	9	4	44.4	4	44.4				
Orange, La.	September 30	5			4	80.0				
Overton, Tex.	August 23	7					1	14.2	2	28.4
Palestine, Tex.	August 10	70	12	17.1	10	14.2	6	8.5	7	10.0
Roosevelt, Tex.	September 24	10	5	50.0						
Sixteen miles south of Roosevelt, Tex.	September 25	2			1	50.0				
Taylor, Tex.	August 16	11	3	27.2			2	18.1		
Trinity, Tex.	August 9	69	12	17.3	9	13.0	7	10.1	12	17.3
Do	August 30	14	1	7.1	5	35.7			2	14.2

TABLE XIX.—*The seasonal distribution of the parasites*—Continued.

Locality.	Date.	Total number of parasites.	Bracon mellitor.		Catolaccus incertus.		Eurytoma tylodermatis.		Cerambycobius cyaniceps.	
			Number.	Percentage.	Number.	Percentage.	Number.	Percentage.	Number.	Percentage.
	1906.									
Victoria, Tex	June 16	15								
Do	June 23	9	5	55.5	2	22.2				
Do	June 25	11	2	18.0	6	54.5				
Do	June 26	20	10	38.4	7	26.9				
Do	June 27	33	15	45.4	8	24.2	1	3.0		
Do	June 28	24								
Do	July 2	24								
Do	July 5	19								
Do	July 9	13	3	23.0						
Do	July 18	32	18	56.2	2	6.2	1	3.1		
Do	July 22	5	3	60.0						
Do	September 1	75	45	60.0	3	4.0	3	4.0	11	14.6
Waco, Tex	July 25	78	25	32.0	6	7.6	3	3.8	4	5.1
Do	August 17	5	1	20.0	1	20.0	1	20.0		
Do	August 28	83	44	54.2			7	8.4	25	29.8
Do	August 29	114	64	56.1	11	9.6	3	2.6	12	10.5
Do	September 19	36	19	52.7	2	5.5	8	22.2	20	55.5
Do	October 12	31								

These figures show very plainly the range of each species and have therefore been used to form a map of the two predominant species throughout the State. The centers of the areas predominated by Catolaccus are Brownsville, Tex., and Orange, La. The influence of Bracon radiates from Goliad and Corsicana, Tex. The center of predominance for Cerambycobius is Marshall, Tex. Eurytoma becomes an active agency at Dallas and Overton, Tex.

BIOLOGICAL NOTES ON THE PARASITES.

1. *Microdontomerus anthonomi* Cwfd. The Torymidæ have always been considered by Dr. William H. Ashmead as parasitic on Diptera. In addition to the records of parasitism upon the boll weevil, which are given on a preceding page, one other specimen was bred September 13, 1905, at Mexia, Tex., by F. C. Pratt from *Brachytarsus alternatus* Say, breeding in the stems of *Sideranthus rubiginosus*. The species is not at all abundant, and has only been collected in cotton forms between August 28 and September 3. It is perhaps a one-generation species, although it may have some other and still unknown host. There is but one individual to each host, and the host may be in the larval or pupal state when attacked. The sexes occurred in the proportion of 2 males and 11 females.

In order to ascertain the length of the developmental periods, the following scheme had to be used: The maximum period from collection to maturity is the nearest approach possible to the total developmental period, and next to this is the total period in a Bracon cocoon in case of hyperparasitism. The maximum period from the observation of the larva to maturity is the nearest approach possible to the total period passed as larva and pupa. The exact length of the pupal period may be defined as between the maximum period from observation of the pupa to maturity and the minimum period from observation of the larva to maturity. Thus it will appear from the following that the total developmental period is over twenty-three days, and the pupal stage lasts from six to nine days during August and September.

TABLE XX.—*Length of developmental periods in Microdontomerus anthonomi.*

Locality.	Date.	Collection to maturity	Larva to maturity.		Pupa to maturity	In Bracon cocoon to maturity.	Development.		
		Maximum.	Minimum.	Maximum.	Maximum.	Maximum.	Total.	Larva + pupa.	Pupa.
	1906.	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*
Cuero, Tex	August 31	14				9			
Goliad, Tex	September 3	23				19	23+		
Hallettsville, Tex	August 30	14	9	9	6				6
Waco, Tex	August 28, 29	10	9	9	5	6			
							23+	23	6–9

It was impossible with a lens to find any characters to distinguish the larvæ of this species from any of the other chalcidoids, as all of the chalcidoid larvæ concerned in this report are finely, transversely lineolate and clad with a few hairs regularly placed in a line around the middle of each segment. The pupa is nearest in appearance to that of Cerambycobius. The female pupa is robust, brown until almost mature, with no darker spots on the dorsal abdominal segments, but with three longitudinal white lines and a transverse white line on each segment; the ovipositor is appressed to the dorsum and proportionately longer than in Cerambycobius. The exuvium is easily recognized by the form of the ovipositor and its brown color. (See figure of pupa and of chalcidoid larva, Pl. I, figs. 4, 7.)

A most interesting point in the biology of this parasite is the fact that a number of individuals were bred from Bracon cocoons. This is one of those phenomena which are here designated as accidental secondary parasitism—that is, where a natural primary parasite finds its host consumed by another parasite and in order to retain its hold on life is compelled to attack that parasite itself.

The breeding records of the parasite are as follows:

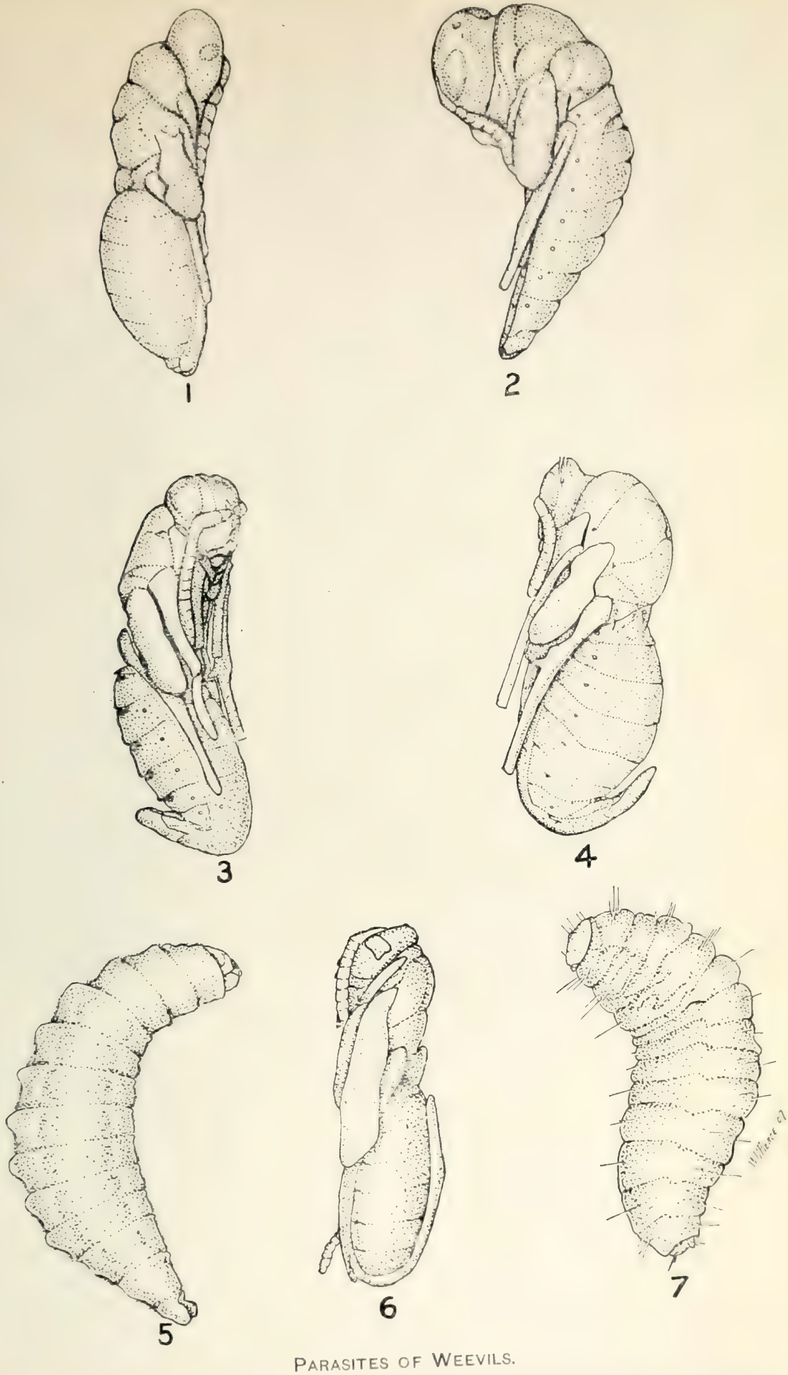
TABLE XXI.—*Breeding records of Microdontomerus anthonomi.*

Locality.	Date.	Total.		As primary parasites.		As secondary parasites.	
		Male.	Female.	Male.	Female.	Male.	Female.
	1906.						
Cuero, Tex	August 31		1				1
Goliad, Tex	September 3		1				1
Hallettsville, Tex	August 30		4		4		
Waco, Tex	August 28		2		2		
Do	August 29	2	3	1	3	1	
		2	11	1	9	1	2

Thirteen parasites were bred, of which 23 per cent were secondary. Owing to numerous expressions of incredulity concerning this dual parasitism it may be proper to state the proofs. In the first place, primary parasitism has been thoroughly established in the case of this species and also in the case of *Eurytoma tylodermatis* and *Cerambycobius cyaniceps.* Adults have been bred from larvæ which were actually observed to be feeding upon the weevil larvæ. The developmental period of those adults bred precludes any arguments that they were bred from unobserved eggs of parasites on the larvæ. In the second place, the Bracon and chalcidoid larvæ are very easily distinguished, so that the notes in most cases stated whether the larva observed was a Bracon or a chalcidoid. In no case was one of the latter bred from a Bracon except when the Bracon cocoon was already formed at the time of the observation. Finally, secondary parasitism was proved because the parasites were actually bred from isolated Bracon cocoons, which were subsequently opened and from which the known exuvia of the secondary parasites were removed.

2. *Eurytoma tylodermatis* Ashm. This species was bred by Townsend in 1895 and by Mally during several years from the boll weevil. Ashmead described it as a parasite of *Tyloderma foveolatum* Say (Ashmead, 1896), a weevil breeding in the stems of *Onagra biennis* and also in a species of Epilobium. It was reared by F. H. Chittenden from the larva of *Tyloderma foveolatum* Say in stems of *Onagra biennis,* September 23, from material collected at Rosslyn, Va.

This species was bred by the writer from *Anthonomus disjunctus* Lec. breeding in the heads of *Heterotheca subaxillaris* at Jacksonville, Tex., October 13, 1905 (1 male); from *Anthonomus squamosus* Lec., breeding in the heads of *Grindelia squarrosa nuda* at Clarendon, Tex., September 22, 1905 (6 females), and September 26, 1905 (2 males); from *Orthoris crotchii* Lec. breeding in the seed pods of *Mentzelia nuda* at Clarendon, Tex., October 2, 1905 (1 male); and from *Lixus musculus* Say, which forms galls in the stems of *Polygonum pennsylvanicum,* at Clarendon, Tex., October 2, 1905 (2 females), and October 17, 1905 (1 male). Mr. W. W. Yothers bred this Eurytoma from *Lixus*



PARASITES OF WEEVILS.

Fig. 1.—*Eurytoma tylodermatis*, pupa. Fig. 2.—*Catolaccus incertus*, pupa. Fig. 3.—*Cerambycobius cyaniceps*, pupa. Fig. 4.—*Microdontomerus anthonomi*, pupa. Fig. 5.—Larva of Bracon. Fig. 6.—*Bracon mellitor*, pupa. Fig. 7.—Larva of chalcidoid. Much enlarged. (Original.)

scrobicollis, which breeds in great abundance in the stems of the common road weeds *Ambrosia trifida* and *A. psilostachya*, at Victoria, Tex., April 5, 1905 (1 female). In a personal letter dated August 30, 1906, Dr. Wm. H. Ashmead writes of this species: "*Eurytoma tylodermatis* Ashm. is another similar case [referring to his remarks on Cerambycobius, given later]. I have had several species of Eurytoma bred by Hopkins, Marlatt, etc., from beetles, and I can only quote their records. The genus seems to be primary and secondary as well as phytophagous, unless we can find characters to still further subdivide it generically."

This parasite is quite abundant throughout the season and is a continuous breeder. The number of generations is probably little less than that of the weevil. There is but one individual to each host, and the latter may be in the larval or pupal state when attacked. The sexes are in the proportion of 29.1 per cent male and 70.9 per cent female. The females are very much larger than the males.

Proceeding in the same manner as for the preceding species it is ascertained that the total developmental period is over 12 to 15 days, that the larval plus pupal period is over 11 to 14 days, and that the pupal period alone is at the minimum 6 days and maximum 13 days. Judging from this last period, for which the figures are definite, it may be safely said that the estimates for the larval and egg periods are very low. The increase in the length of the pupal period in October is noticeable.

The data upon the biology of *Eurytoma tylodermatis* are comparatively continuous from July 18 to October 19. In studying the length of the various stages the same methods were used as outlined for Microdontomerus. The only stage which could be definitely limited as to the period of development was the pupal stage, which was found to last from 7 to 8 days in the latter half of July, 6 to 9 days during August, 7 to 9 days in September, and 11 to 13 days in October.

The larvæ of Eurytoma were described in the notes as smooth, transversely lineolate, and with wrinklings at the sutures. The pupæ are white, pink-eyed, turning black toward maturity. They may be easily distinguished, by the lateral compression of the abdomen and the straight venter, from the pupæ of Catolaccus with their dorso-ventral compression and obtusely angulated venter. The exuvium is cast in parts and is never found intact as in the case of the other chalcidoids studied; the remains are yellowish transparent. (See figure of pupa, Pl. I, fig. 1.)

Secondary parasitism: One male was bred from material collected August 9 at Trinity, Tex., and two males from material collected September 19 at Waco, Tex., as secondary parasites in the cocoons of *Bracon mellitor*. In each case the cocoon was isolated when first found, so that no doubt could be expressed as to the source of the parasites. Corroboration was obtained by examining the cocoons.

3. *Bruchophagus herreræ* Ashm. Considerable doubt has been raised by very eminent parasitologists as to the actual parasitism of the boll weevil by this species and some doubt has been raised concerning its generic location. No subsequent corroboration has been obtained to prove parasitism of the boll weevil.

4. *Cerambycobius cyaniceps* Ashm. The first published record of the parasitism of the boll weevil by this species is found in Mally's Report (Mally, 1902), in which that writer states that he had bred it since 1899 at Austin, Tex. Only four records were obtained in previous years by the boll-weevil laboratory of the Bureau of Entomology; 1 female bred July 7 at Calvert, Tex., by G. H. Harris; 1 male and 1 female bred July 25 at Victoria, Tex., by W. E. Hinds, and 1 female bred March 11 at Corsicana, Tex., by C. M. Walker.

Dr. F. H. Chittenden has reared it from the larva of *Tyloderma foveolatum* breeding in the stems of *Onagra biennis*, September 11, from material collected at Chevy Chase, Md. He has also reared it from *Bruchus exiguus* Horn (Chittenden, 1893b). In a personal letter dated August 30, 1906, Dr. Wm. H. Ashmead said of this species: "It is not rare, has been bred from cerambycids and other beetles, and I have always supposed it to be a primary parasite. All of these beetles, however, have braconid parasites, and it may yet prove to be a secondary parasite as other of the eupelmines are said to be."

One female was bred by the writer October 17, 1905, as a probable parasite of *Lixus musculus* Say, breeding in stem galls of *Polygonum pennsylvanicum* collected September 19 at Clarendon, Tex. On October 26, 1906, a female was bred from a *Lixus musculus* pupa collected in the same plant at Dallas, Tex., opposite the farm on which release experiments were conducted. On September 11 and 12, 1906, 2 females were bred from *Anthonomus albopilosus* breeding in seed of *Croton engelmanni* collected August 26, 1906, at Johnsons Bayou, La., by J. D. Mitchell. On October 30, 1906, 1 female was bred from *Trichobaris texana* found breeding in stalks of *Solanum rostratum* by R. A. Cushman and the writer, along the road close to the plat upon which parasites were released at Dallas.

This parasite is very abundant in eastern Texas, diminishing to the Southeast, and is entirely absent at Brownsville and through western Texas. It is a continuous breeder, attacking the weevil larvæ and pupæ, one individual for each host. The sexes are in the proportion 19.7 per cent males and 80.3 per cent females. The females are several times longer than the males.

The developmental periods for *Cerambycobius cyaniceps* have been worked out from data covering the period between July 12 and October 4. The pupal period in July is 10 days or less, in August is from

8 to 11 days, and in September from 9 to 12 days. During August it was ascertained that the entire developmental period exceeds 26 days.

The larvæ of Cerambycobius are described in the breeding notes as white, transversely lineolate, with a row of prominent hairs around the middle of each segment. The pupæ are elongate brown, with a short, obtuse, erect ovipositor, and with the dorsum of the abdomen marked with two dark spots on each segment. The brown exuvium is easily recognized from the ovipositor. The pupæ may be easily distinguished from those of Microdontomerus after a little practice. (See figure of pupa, Pl. I, fig. 3.)

Secondary parasitism: On September 14 a female Cerambycobius was bred from a larva which was found feeding on a Catolaccus pupa in material collected August 28 at Calvert. Although numerous cases of parasitism of *Bracon mellitor* were found, only 11.5 per cent of this species were secondary parasites. It was found as a secondary parasite on Bracon as follows:

Beeville, Tex., July 12, 1 female.
Corpus Christi, Tex., July 10, 1 female.
Cuero, Tex., August 31, 1 female.
Mansfield, La., August 24, 2 females.
Trinity, Tex., August 9, 1 male, 1 female.
Victoria, Tex., September 1, 1 female.
Waco, Tex., August 28, 3 males, 10 females.
Waco, Tex., September 19, 1 male, 2 females.

In one case the attack of the Bracon is known to have been prior to spinning.

5. *Catolaccus incertus* Ashm. This species has been one of the most important species mentioned in the literature of the boll weevil. It was described as a primary parasite of *Anthonomus signatus* (Chittenden, 1893a). It was reared by F. H. Chittenden from *Apion decoloratum* Sm. breeding in *Meibomia paniculata* at Washington, D. C., from *Apion griseum* Sm. breeding in *Phaseolus perennis* at Washington, D. C., and from *Bruchus exiguus* (Chittenden, 1893b).

Two females were bred by the writer October 16, 1905, from *Anthonomus disjunctus* breeding in the heads of *Heterotheca subaxillaris* collected at Jacksonville, Tex. From *Anthonomus eugenii* breeding in peppers at San Antonio, Tex., F. C. Pratt bred 3 females on October 18, 1905. From *Anthonomus albopilosus* breeding in the seed of *Croton engelmanni* at Johnsons Bayou, La., the writer bred 2 females on September 6, 1906, and from the same weevil breeding in *Croton capitatus* at Leesville, La., the writer bred 1 female on September 29, and subsequently 3 females and 3 males.

Catolaccus incertus is very common in all parts of the State and is well established as a boll weevil parasite. (See Plate III, *E*.) It is a continuous breeder, attacking the weevil larvæ and pupæ, one individual for each host. The developmental period seems to be considerably shorter than in either of the species preceding. The data upon which the following figures are based cover the period from June 25 to October 28. During June and July the total developmental period is known to be over 11 or 12 days, during August it is over 14 days, and during September and October over 18 days. The pupal period in June and July is only 4 to 6 days, in August 6 to 7 days, in September 5 to 9 days, but in October 13 to 15 days.

The larvæ of Catolaccus were described in the notes as having short hairs in a row on each segment. The pupæ are white to yellow, the thorax turning black first as they approach maturity. The abdomen is very flat below and bent at an obtuse angle to the thorax. The head is very broad, and the eyes are pink. The exuvium is yellowish and resembles a little pointed cap. (See figure of pupa, Pl. I, fig. 2.)

6. *Sigalphus curculionis* Fitch. No corroboration has been recorded of the parasitism of the boll weevil by this species. This parasite is very commonly bred from the plum curculio (*Conotrachelus nenuphar* Hbst.). Chittenden also records it as a primary parasite of *Trichobaris trinotata* Say, which breeds in the stems of *Solanum rostratum* (Chittenden, 1902).

7. *Urosigalphus anthonomi* Cwfd. This parasite was again bred September 20 from material collected September 5 at Brownsville. The period in the cocoon was at least 9 days. The cocoon with weevil larva's head attached was half in a cotton seed in a boll. It was very much finer meshed than that of *Bracon mellitor* and easily broken. In addition to this species and (8) *Urosigalphus schwarzi* Cwfd., both bred from *Anthonomus grandis*, *Urosigalphus armatus* Ashm. has been bred from Balaninus, and another species (*Urosigalphus bruchi* Cwfd.) from *Bruchus prosopis* Lec. taken at Harlingen, Tex., in beans of *Prosopis glandulosa*. Hence it is very probable that the species of this genus are normally weevil parasites.

9, 10. *Bracon mellitor* Say. *Bracon dorsator* Say. *Bracon xanthostigma* Cress.

These are all forms of a single very variable species, of which the entirely red form holds the name *B. mellitor*, that with black sternum and metathorax the name *B. xanthostigma*, and that with the thorax almost entirely black and the vertex of the head also black, being also smaller in size, has been known as *B. dorsator*.

A peculiar record is furnished by F. H. Chittenden who reared this species from the strawberry leaf-roller *Ancylis* (*Phoxopteris*) *comptana* Fröl., from material collected at Cabin John, Md., July 9, 1899.

In a personal letter dated August 30, 1906, Dr. Wm. H. Ashmead writes: "*Bracon mellitor* Say is undoubtedly a most important parasite, widely distributed in the United States, and must affect very many different beetles, although usually rhynchophorous beetles."

The typical form has been bred from *Anthonomus grandis* at all times and in all places between June 15 and October 4. The form *xanthostigma* has only been bred from the boll weevil between September 16 and April 28, while *dorsator* was bred August 2, 1903, at Victoria; November 20, 1895, at Goliad, and December 17, 1895, at Beeville. *B. mellitor* was bred June 19, 1905, at Dallas by W. W. Yothers from *Anthonomus fulvus* Lec., which breeds in the buds of *Callirrhoe involucrata*, and on June 14 he bred *dorsator* from the same weevil. On September 20, 1905, F. C. Pratt bred male and female *dorsator* and female *mellitor* from *Desmoris scapalis* Lec., breeding in the flower heads of *Sideranthus rubiginosus* at Mexia, Tex.; on September 23 he bred the typical form from the same weevil collected at Calvert, Tex.; on September 29 both the typical form and *dorsator* from Mexia material; and on October 27 he again bred the typical form from Mexia material. On September 30, 1905, the writer bred *mellitor* and *xanthostigma* from *Anthonomus squamosus* Lec., breeding in the heads of *Grindelia squarrosa nuda* at Clarendon, Tex.; on October 2, 4 of the typical form and 1 *xanthostigma* were bred; on October 3, 3 typical, and finally on October 16 a *xanthostigma*, were bred. On October 18 and 23 *dorsator* was bred by F. C. Pratt from *Anthonomus eugenii* Cano, breeding in peppers at San Antonio, Tex. On September 6, 1906, J. D. Mitchell bred a typical form from *Anthonomus albopilosus* Dietz, breeding in seed of *Croton capitatus* at Victoria, Tex.

The data upon the life-cycle of *Bracon mellitor* cover the period from June 25 to November 15. The entire developmental period covers at least 21 days in June and 33 in October, but probably considerably more. The period within the cocoon has been limited to between 5 and 6 days in June, to 7 days in July, 6 to 11 days in August, 3 to 7 days in September, and 15 to 27 days in October. The minimum of 3 days in September is based upon an observation of the spinning of the cocoon and the time of maturity, and the record of 5 days in June was obtained in the same manner.

The larvæ of Bracon can be immediately separated by the absence of hairs and by the body being punctate instead of lineolate. The pupæ are yellowish, loosely constructed, with the appendages very fragile and inclosed in a stout one-meshed silken cocoon, which varies from pure white to golden yellow or dark brown. In several cases where particular note was made of the brown color of the cocoon hyperparasites were bred, but this was not a constant indication. The species varied greatly in size, depending upon the amount of food available. (See figures of larva and pupa, Pl. I, figs. 5, 6.)

No dark forms of this species were bred until September 10, 1906, except a single *B. dorsator* which was bred from Cuero material collected August 31. The rest were all bred from material collected at Brownsville, September 29; Dallas, October 2, 6, 10; and Waco, October 12. The record of all Bracon bred after October 10 is as follows:

October	10,	*Bracon mellitor*, 3 males, 5 females.
	11,	Do. 1 male.
	12,	Do. 1 male.
	13,	Do. 1 female; *mellitor xanthostigma*, 2 females.
	15,	Do. 1 female.
	18,	*Bracon mellitor xanthostigma*, 3 females.
	20,	Do. 2 females.
	22,	*Bracon mellitor*, 3 females; *mellitor xanthostigma*, 2 females; *mellitor dorsator*, 2 males, 1 female.
	24,	*Bracon m. xanthostigma*, 1 female.
	25,	Do. 2 females; *m. dorsator*, 1 female.
	31,	Do. 2 females.
November	1,	Do. 3 females; *m. dorsator*, 1 male.
	5,	Do. 1 female.
	6,	*Bracon mellitor dorsator*, 1 female.
	14,	*Bracon mellitor xanthostigma*, 1 female.

11. An undetermined braconid of the size of *Bracon mellitor*, but with the base of the abdomen black and belonging to a different subfamily, was bred September 17 from a yellow cocoon in a fallen square collected at Victoria, Tex., September 1. Unfortunately this was lost in the mails.

12. *Myiophasia ænea* Wied. This species is recorded as a parasite of *Balaninus nasicus* Say, *Chalcodermus* sp., *Conotrachelus juglandis* Lec., and *Sphenophorus parvulus* Gyll. (Coquillett, 1897), and also of *Ampeloglypter sesostris* Lec. (Aldrich, 1905). One specimen was bred July 6 by the writer from a larva of *Conotrachelus affinis* Boh. found in a hickory nut collected June 8 at Logansport, La. As parasites of the boll weevil from fallen squares collected at Many, La., August 23, 1 male was bred September 5 and 1 female September 8, while 1 failed to mature. From a hanging square collected at Waco, Tex., August 29, a puparium was obtained but the fly not bred. From a small boll collected at Victoria, Tex., July 12, a deformed fly was bred.

Parasitism by this species can always be positively proved if the puparium is found, as it is inside of the stretched skin of the weevil larva. The affected larva is of a tawny parchment color and shows the projections of the appendages of the fly puparium.

The developmental period is undoubtedly in excess of 28 days, as shown by the first record above.

13. Several attempts have been made to introduce *Pediculoides ventricosus* Newp. into Texas as a parasite of the boll weevil, but

with no success. Much has been written upon this mite by Professor Herrera and his staff.

14. There are, however, native mites, including *Tyroglyphus breviceps* Banks (Banks, 1906, p. 17), which in some cases are a considerable factor in the destruction of the immature weevils. At Calvert, Tex., in moist fallen squares collected September 13, 11 out of 18 cases of parasitism were mites. *T. breviceps* was described from Victoria.

15. *Hydnocera pubescens* Lec. This clerid was found to be predaceous in its larval stage upon the boll weevil and all of its parasites. The egg is probably inserted into the cell of the weevil, and the young predator immediately starts its attack, consuming whatever it finds in the way of insects, and finally spins a loosely meshed, single-layer, silken cocoon, and pupates therein. From data of material collected at Waco, Tex., August 28, an approximation of the developmental periods was obtained. The longest period from collection to spinning was 34 days, the period in the cocoon was 12 days, the adult being formed 3 days before leaving the cocoon. In order to prove the predaceous habit live weevil pupæ were furnished individual clerid larvæ, and in most cases were completely consumed. In several cases large larvæ were found in Bracon cocoons which were punctured with holes large enough only for the very smallest of the larvæ.

16. In a number of cases, material collected at Victoria, Dallas, and Brownsville gave evidence of a predaceous attack upon weevil stages by *Cathartus cassiæ* Reiche.

IV. The Sources of the Parasites.

In the preceding sections it has been pointed out that the parasites of *Anthonomus grandis* are also common to various other species of weevils. There is a more or less clearly defined theory in parasitology that the parasites of a particular genus or tribe are confined to the insects of a particular family or order. With this idea in mind a list of the known parasites of the Rhynchophora has been compiled, in order to show the characteristic groups and the possible sources of boll-weevil parasites.

PARASITES KNOWN TO ATTACK RHYNCHOPHORA.

Parasite.	Host.
Fungi.	
Aspergillus sp	*Anthonomus grandis* Boh.
Cordyceps sp	*Anthonomus grandis* Boh.
Empusa (*Entomophthora*) *sphærosperma*	*Phytonomus punctatus* Fab.
Entomophthora phytonomi	*Phytonomus punctatus* Fab.
Sporotrichum globuliferum	*Epicærus imbricatus* Say.

Parasite.	Host.
Acarina.	
Tarsonemidæ.	
Pediculoides ventricosus Newp	*Anthonomus eugenii* Cano.
	Anthonomus grandis Boh.
Tyroglyphidæ.	
Tyroglyphus breviceps Banks	*Anthonomus grandis* Boh.
(?)	*Anthonomus eugenii* Cano.
Diptera.	
Dexiidæ.	
Metadexia basalis G. T.	*Conotrachelus juglandis* Lec.
Tachinidæ.	
Myiophasia ænea Wied	*Ampeloglypter sesostris* Lec.
	Anthonomus grandis Boh.
	Balaninus nasicus Say.
	Chalcodermus æneus Boh.
	Conotrachelus affinis Boh.
	Conotrachelus juglandis Lec.
	Sphenophorus parvulus Gyll.
Myiophasia robusta Coq	*Sphenophorus robustus* Horn.
Hymenoptera.	
Proctotrypoidea.	
Platygasteridæ. Platygasterinæ.	
Trichacis rufipes Ashm	*?Balaninus nasicus* Say.
Chalcidoidea.	
Torymidæ. Monodontomerinæ.	
Microdontomerus anthonomi Cwfd	*Anthonomus grandis* Boh.
	Brachytarsus alternatus Say.
Eurytomidæ. Eurytomini.	
Eurytoma magdalidis Ashm	*Magdalis armicollis* Say.
Eurytoma tylodermatis Ashm	*Anthonomus disjunctus* Lec.
	Anthonomus grandis Boh.
	Anthonomus squamosus Lec.
	Apion segnipes.[a]
	Lixus musculus Say.
	Lixus scrobicollis Boh.
	Orthoris crotchii Lec.
	Tyloderma foveolatum Say.
Bruchophagus herreræ Ashm	*Anthonomus grandis* Boh.
Cleonymidæ. Cleonyminæ.	
Cheiropachys colon L	*Magdalis ænescens* Lec.
Encyrtidæ. Eupelminæ. Eupelmini.	
Cerambycobius cyaniceps Ashm	*Anthonomus grandis* Boh.
	Anthonomus albopilosus Dietz.
	Bruchus exiguus Horn.[a]
	Lixus musculus Say.
	Trichobaris texana Lec.
	Tyloderma foveolatum Say.[a]
Pteromalidæ. Pteromalinæ. Metaponini.	
Bruchobius laticollis Ashm	*Bruchus pisorum* L.
Pteromalidæ. Pteromalinæ. Rhaphitelini.	

[a] On the authority of F. H. Chittenden.

Parasite.	Host.
Chalcidoidea—Continued.	
Dinotus sp.	*Magdalis ænescens* Lec.
Pteromalidæ Pteromalinæ. Pteromalini.	
Catolaccus anthonomi Ashm	*Anthonomus signatus* Say.
Catolaccus cœliodis Ashm	*Acanthoscelis acephalus* Say.
Catolaccus incertus Ashm	*Anthonomus æneolus* Dietz.
	Anthonomus eugenii Cano.
	Anthonomus albopilosus Dietz.
	Anthonomus disjunctus Lec.
	Anthonomus fulvus Lec.
	Anthonomus grandis Boh.
	Anthonomus nigrinus Boh.
	Anthonomus signatus Say.
	Apion decoloratum Sm.[a]
	Apion griseum Sm.[a]
	Auletes tenuipes Lec.
	Bruchus exiguus Horn.[a]
	Zygobaris xanthoxyli Pierce.
Neocatolaccus tylodermæ Ashm	*Lixus parcus* Lec.
	Lixus musculus Say.
	Tyloderma foveolatum Say.
Pteromalidæ. Spalangiinæ.	
Cerocephala pityophthori Ashm	*Pityophthorus consimilis* Lec.
Cerocephala scolytivora Ashm	A scolytid.
Eulophidæ. Entedoninæ. Omphalini.	
Omphale livida Ashm	*Ceutorhynchus rapæ* Gyll.
Eulophidæ. Entedoninæ. Entedonini.	
Asecodes albitarsis Ashm	*Magdalis ænescens* Lec.
Entedon lithocolletidis Ashm	*Anthonomus nigrinus* Boh.
Eulophidæ. Tetrastichinæ. Tetrastichini.	
Tetrastichus sp	*Orthoris crotchii* Lec.
Mymaridæ. Mymarinæ. Anaphini (egg parasites).	
Anaphes conotracheli Girault	*Conotrachelus nenuphar* Hbst.
Ichneumonoidea.	
Ichneumonidæ. Ophioninæ. Porizonini.	
Porizon conotracheli Riley	*Conotrachelus nenuphar* Herbst.
Braconidæ. Blacinæ. Calyptini.	
Calyptus tibiator Cress	*Anthonomus signatus* Say.
Braconidæ. Sigalphinæ.	
Sigalphus canadensis Prov	*Anthonomus scutellatus* Gyll.
Sigalphus copturi Riley ms	*Podapion gallicola* Riley.[b] *Cylindrocopturus longulus* Lec.[b] *Conotrachelus posticatus* Boh.

[a] On the authority of F. H. Chittenden.

[b] Breed together.

Parasite.	Host.
Ichneumonoidea—Continued.	
Sigalphus curculionis Fitch	*Anthonomus grandis* Boh.
	Conotrachelus juglandis? in nuts.
	Conotrachelus nenuphar Hbst.
	Trichobaris trinotata Say.
Sigalphus sp	*Chalcodermus æneus* Boh.
Sigalphus zygobaridis Cwfd	*Zygobaris xanthoxyli* Pierce.
Urosigalphus anthonomi Cwfd	*Anthonomus grandis* Boh. (Texas).
Urosigalphus armatus Ashm	*Balaninus* spp., *Conotrachelus* spp.
Urosigalphus bruchi Cwfd	*Bruchus prosopis* Lec.
Urosigalphus schwarzi Cwfd	*Anthonomus grandis* Boh. (Guatemala).
Braconidæ. Cheloninæ.	
Phanerotoma tibialis Hald	*Anthonomus nigrinus* Boh.
Braconidæ. Agathidinæ. Microdini.	
Microdus simillimus Cress	*Lixus scrobicollis* Boh.
Braconidæ. Braconinæ. Braconini.	
Glyptomorpha lixi Ashm	*Lixus scrobicollis* Boh.
Glyptomorpha mavaritus Cress	*Lixus scrobicollis* Boh.
Glyptomorpha novitus Cress	*Lixus musculus* Say.
Glyptomorpha rugator Say	*Lixus concavus* Say.
	Lixus musculus Say.
Vipio belfragei Cress	*Lixus scrobicollis* Boh.
Melanobracon simplex Cress	*Dendroctonus piceæperda* Hopk.
Microbracon nuperus Cress	*Orthoris crotchii* Lec.
Bracon analcidis Ashm	*Tyloderma fragariæ* Riley.
Bracon anthonomi Ashm	*Anthonomus signatus* Say.
Bracon mellitor Say	*Anthonomus eugenii* Cano.
	Anthonomus albopilosus Dietz.
	Anthonomus fulvus Lec.
	Anthonomus grandis Boh.
	Anthonomus squamosus Lec.
	Desmoris scapalis Lec.
Bracon pissodis Ashm	*Pissodes strobi* Peck.
Bracon rhyssemati Ashm. ms	*Rhyssematus lineaticollis* Say.
Bracon smicronygis Ashm. ms	*Smicronyx tychoides* Lec.
Bracon sp	*Tomicus pini* Say.
Bracon sp	*Brachytarsus limbatus* Say.
Bracon sp	*Baris* sp.
Braconidæ. Rhogadinæ. Rhyssalini.	
Rhyssalus pityophthori Ashm	*Pityophthorus* sp.
Braconidæ. Spathiinæ. Spathiini.	
Spathius canadensis Ashm	*Dryocœtes autographus* Ratz.
	(?) *Magdalis olyra.*
	Phlœosinus graniger Chap.
	Tomicus sp.

BIOLOGIES OF THE WEEVILS CONTRIBUTING PARASITES.

It is of considerable importance in framing means of combating the boll weevil with parasites that the weevils usually found in the vicinity of cotton fields should be thoroughly known. In order that the conclusions in this regard may be more thoroughly understood, this subject must be introduced by a series of brief biologies of all the weevil species which have contributed parasites to the attack of the boll weevil.

CURCULIONIDÆ. APIONINÆ.

1. *Apion decoloratum* Sm. breeds in *Meibomia paniculata*. It is parasitized at Washington, D. C., by *Catolaccus incertus*.

2. *Apion griseum* Sm. breeds in *Phaseolus perennis*, and is parasitized by the same species as the preceding.

CURCULIONINÆ. CLEONINI.

3. *Lixus musculus* Say makes a gall in the stems of *Polygonum pennsylvanicum*. The larvæ and pupæ are found in these galls. The weevil and its host plant are typical of tne fall, the plant being found in low moist ground, frequently in close proximity to cotton fields. The weevil is attacked by two of the important boll-weevil parasites.

4. *Lixus scrobicollis* Say dwells in the stems of *Ambrosia trifida* and *psilostachya*, two of the commonest roadside and waste-place weeds throughout the country in summer and fall. The entire stem is riddled by the weevil larvæ, which pupate in cells of frass at the end of their burrows. *Eurytoma tylodermatis* and other parasites not concerned in the discussion have been bred from this weevil.

ERIRHININI.

5. *Desmoris scapalis* Lec. breeds in the seed heads of *Sideranthus rubiginosus*, a summer weed, which is very abundant in some localities along roadsides and on prairies. The larvæ are expelled with the seed and enter the ground for pupation, maturing in the following spring. This species is parasitized by *Bracon mellitor*, which has a much more rapid development than its host. (See Pl. III, *B*, *D*, *F*, *G*.)

ANTHONOMINI.

6. *Anthonomus* (*Anthonomorphus*) *fulvus* Lec. breeds in the buds of *Callirrhoe involucrata*, an early spring mallow, which is common in May and June on moist meadows. The larvæ feed upon the floral column of the bud or the imperfectly opened flower and pupate in a cell of excreta in the capsule or fallen corolla. *Bracon mellitor* and *Catolaccus incertus* have been bred from it. (See Pl. II.)

7. *Anthonomus signatus* Say, the strawberry weevil, breeds in a number of rosaceous plants, such as strawberry, blackberry, raspberry, and wild rose, as also in red-bud. It is an early spring weevil, ovipositing in the buds, which soon drop to the ground, where the larva transforms to the pupa stage. It is parasitized by *Catolaccus incertus*.

8. *Anthonomus nigrinus* Say is an eastern weevil which breeds in the buds of *Solanum carolinense* and various other solanaceous plants, occurring principally in the spring and early summer, but not confined to one generation. It oviposits in the buds, causing them to fall. The larva makes its cell in the center of the bud through the pistil and all of the stamens and pupates in this cell. It is a host of *Catolaccus incertus*.

9. *Anthonomus albopilosus* Dietz is a fall species which breeds in the seed of *Croton capitatus* and *C. engelmanni*, weeds which are very abundant in pastures. The larvæ eat out one seed and then enter a second and form their pupal cell in this. The weevil serves as a host to *Cerambycobius cyaniceps*, *Catolaccus incertus*, and *Bracon mellitor*.

10. *Anthonomus æneolus* Dietz is a spring species which breeds in the buds of *Solanum torreyi*, *S. rostratum*, and *S. eleagnifolium*. The larvæ feed within one or two anthers, in the latter case forming a cell which cements the two together. In many cases the flower does not fall, and is able to fruit. The weevil is a host of *Catolaccus incertus*.

11. *Anthonomus eugenii* Cano (*æneotinctus* Champ.), the pepper weevil, is a recent introduction from Mexico. It is a fall species, which breeds in the interior of the cultivated peppers. (See Plate III; *A*, *C*.) It is a host to *Catolaccus incertus*, *Bracon mellitor*, and *Pediculoides ventricosus*, as determined by Professor Herrera. *Anthonomus mexicanus* Boh., another pepper weevil, is very likely identical.

12. *Anthonomus squamosus* Lec. breeds in the heads of *Grindelia squarrosa*, a fall plains plant, which is very abundant in semiarid Texas. The weevil larva makes a cell among the seed, which is formed of the hardened gum of the flower and excreta. It has probably only one generation. It is very highly parasitized and principally by *Bracon mellitor* and *Eurytoma tylodermatis*.

13. *Anthonomus disjunctus* Lec. breeds in the heads of *Heterotheca subaxillaris*, a fall plant, which is very abundant along roads, waste places, and on meadows. The weevil larva makes a small cell, formed of the hardened gum and excreta of the weevil, among the seed. There is but one generation. *Eurytoma tylodermatis* and *Catolaccus incertus* have both been bred from this weevil.

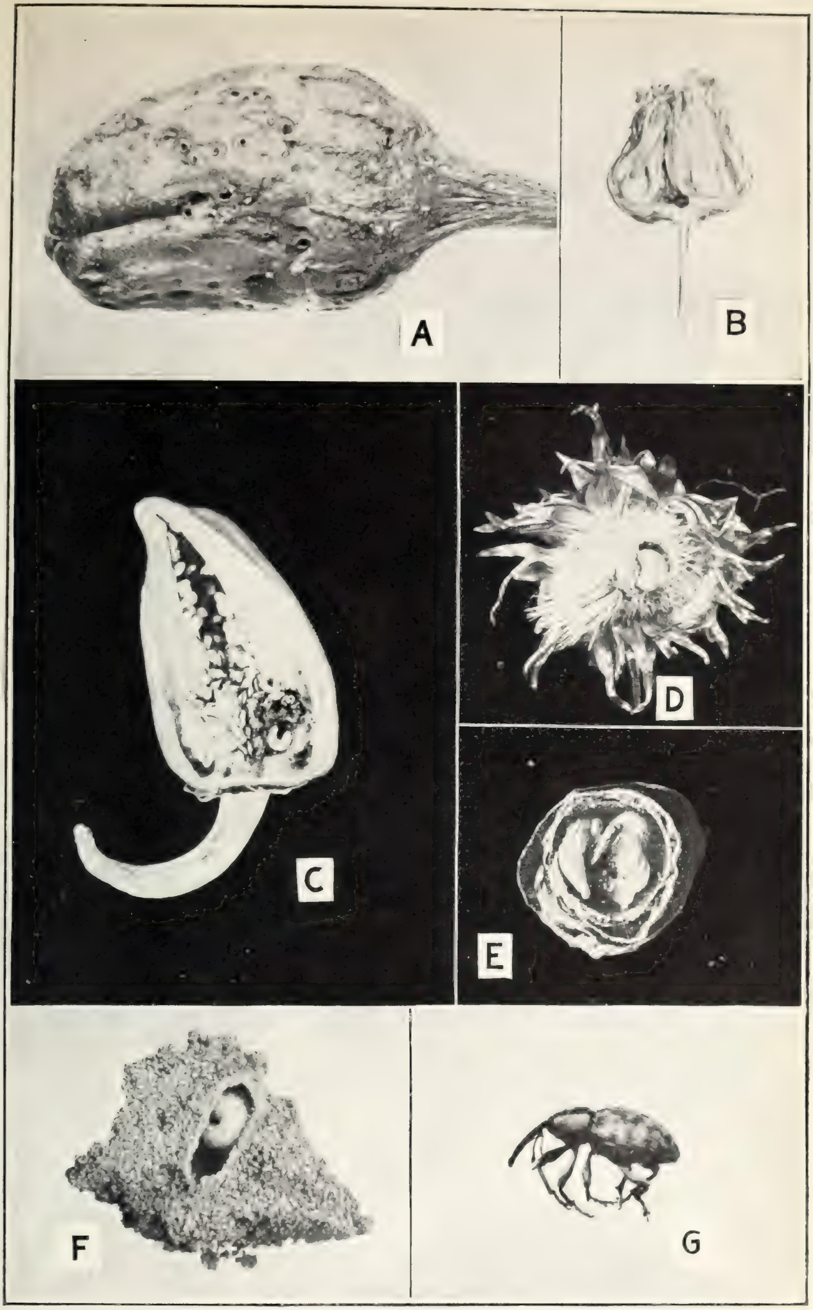
CRYPTORHYNCHINI.

14. *Conotrachelus affinis* Boh., the hickory nut weevil, has been found to be the host of *Myiophasia ænea*. It is an early summer weevil. Pupation is in the ground.

15. *Conotrachelus nenuphar* Herbst, the plum and peach curculio, breeds in the fleshy part of the fruit and pupates in the ground. It is the host of *Sigalphus curculionis*, which has once been bred from *Anthonomus grandis*.

THE PURPLE MALLOW (CALLIRHOE INVOLUCRATA), A FOOD PLANT OF TWO WEEVILS RELATED TO THE BOLL WEEVIL.

Fig. A.—The buds and flowers, which are subject to attack by *Anthonomus fulvus*, and the capsule, subject to attack of *Macrorhoptus estriatus*. Fig. B.—Bud infested by *Anthonomus fulvus*. Fig. C.—Flower injured by adult weevil of *Anthonomus fulvus*. (Original.)



BIOLOGIES OF WEEVILS.

Fig. A.—Pepper, showing egg punctures of *Anthonomus eugenii*. Fig. B.—Head of *Sideranthus rubiginosus*, showing cell of *Desmoris scapalis*. Fig. C.—Pepper, showing larva of *Anthonomus eugenii* in situ. Fig. D.—Head of *Sideranthus rubiginosus*, with larva of *Desmoris scapalis* in its cell. Fig. E.—Section of cotton square, showing pupa of *Anthonomus grandis* and pupa of primary parasite *Catolaccus incertus*. Fig F.—Earthen cell of larva of *Desmoris scapalis*. Fig. G.—*Desmoris scapalis*, adult weevil. (Original.)

16. *Chalcodermus æneus* Boh. is the cowpea-pod weevil, although it has once been bred from a cotton square. It is recorded as a host of *Myiophasia ænea.*

17. *Tyloderma foveolatum* Say breeds in the stems of *Onagra biennis,* an early summer evening primrose. Pupation takes place in the larval burrow. It is parasitized by *Eurytoma tylodermatis* and *Cerambycobius cyaniceps.*

CEUTORHYNCHINI.

18. *Auletes tenuipes* Lec. This species was found to breed in the buds of *Galpinsia hartwegi* at Dallas in the spring. The larvæ feed within a single anther in the bud, leaving it when the flower opens and entering the ground for pupation. The entire life cycle does not exceed 25 days, of which 11 days only is spent in the bud. *Catolaccus incertus* has been bred as a parasite.

BARINI.

19. *Orthoris crotchii* Lec. is a very abundant fall weevil in western Texas, breeding in the seed pods of *Mentzelia nuda,* a plains plant. Pupation is in a cell formed within several seeds. The species is highly parasitized by several species, the least of which, however, is *Eurytoma tylodermatis.*

20. *Trichobaris texana* Lec. is a stalk weevil, breeding in the stems of *Solanum rostratum,* a plant common in waste places in the summer and fall. The weevil cells are not more than an inch apart throughout the stem. *Cerambycobius cyaniceps* has been bred as a parasite.

21. *Trichobaris trinotata* Say, the potato stalk weevil, is another host of *Sigalphus curculionis.*

22. *Ampeloglypter sesostris* Lec. is a grapevine weevil, and a host of *Myiophasia ænea.* It is not recorded from Texas.

23. *Zygobaris xanthoxyli* Pierce. This new species breeds in the berries of Xanthoxylum at Runge and Beeville, Tex., in the spring. The larvæ feed in the interior of the seed until the seed is thrown to the ground. They then enter the soil and pupate in a tiny earthen cell, being in the ground about a month. *Catolaccus incertus* has been bred as a parasite.

ANTHRIBIDÆ.

24. *Brachytarsus alternatus* Say breeds in the stems of *Sideranthus rubiginosus.* It is a constant breeder, entirely riddling the stems. Microdontomerus has been bred from it.

BRUCHIDÆ.

Although not considered Rhynchophora by American writers, it is very probable that the Bruchidæ are a connecting link between the Anthribidæ and Chrysomelidæ.

25. *Bruchus exiguus* Horn breeds in the seed pods of *Amorpha fruticosa* in the fall. It is a host of *Cerambycobius cyaniceps* and *Catolaccus incertus*.

It is noticeable from the foregoing that *Bracon mellitor* attacks bud, flower, pod, and seed weevils; *Catolaccus incertus* attacks bud, pod, and seed weevils; *Cerambycobius cyaniceps* attacks bud, pod, and seed, but mainly stem weevils; *Eurytoma tylodermatis* attacks bud, flower, pod, and stem weevils; *Microdontomerus anthonomi* attacks bud, capsule, and stem weevils; *Myiophasia ænea* attacks bud, fruit, pod, nut, and stem weevils, and *Sigalphus curculionis* attacks bud, fruit, pod, and stem weevils. Such general habits indicate a generalization of habit in the species concerned and give promise of the possibility of more extensive adaptation to the boll weevil as a host.

ROTATION OF HOSTS.

The most important item in the solution of the parasite question is probably concerned with the treatment of the other hosts. It is found that the parasites which now attack the weevil are naturally parasitic on weevils of short season and few generations, and the most feasible proposition is that of forcing them to attack the boll weevil only.

Two lines of action are suggested as possible and practicable. The first is, that such plants as the Crotons, hosts of *Anthonomus albopilosus*, might be planted in abundance in the pastures because they make good feed and are easily destroyed, and that thus the weevils and their parasites would increase in great numbers and the latter might perhaps attack the boll weevil.

The counter proposal is that the timely elimination of the summer series of host plants would cut off the possibility of finding any host but the boll weevil, which would be in abundance. The cutting of the weeds around the fields could not result disadvantageously, as there are numerous pests harbored by these same weeds. At present the information as to the rotation of hosts is incomplete, and it is therefore necessary to go very fully into this question as well as to test both methods which have been suggested.

The known hosts of *Bracon mellitor* would insure it an uninterrupted rotation if they all occurred in a given locality. They do not, so there are still other unfound hosts of this species. The season of its hosts as far as known are as follows:

Anthonomus fulvus breeds from May 3 to July 12.
Desmoris scapalis breeds from July 25 to September 22.
Anthonomus squamosus breeds from August 11 to September 19.
Anthonomus albopilosus breeds from August 26 to September 29.
Anthonomus eugenii breeds from October 6 to October 31.

Important gaps exist in the host rotation of *Catolaccus incertus*. Its hosts breed as follows:

Anthonomus signatus breeds from April 11 to June 12.
Anthonomus fulvus breeds from May 3 to July 12.
Auletes tenuipes breeds from May 9 to May 25.
Zygobaris xanthoxyli breeds from May 11 to June 29.
Anthonomus æneolus breeds from May 17 to July 12.
Anthonomus nigrinus breeds from June 30 to July 18.
Anthonomus albopilosus breeds from August 26 to September 29.
Anthonomus eugenii breeds from October 6 to October 31.
Anthonomus disjunctus was found breeding October 11 to 14.

The known habits of the hosts of *Cerambycobius cyaniceps* are as follows:

Tyloderma foveolatum breeds from June 22 to September 23.
Trichobaris texana breeds from June 26 to October 11.
Lixus musculus breeds from August 11 to September 19.
Anthonomus albopilosus breeds from August 26 to September 29.

The following data comprise all that is known of the hosts of *Eurytoma tylodermatis:*

Tyloderma foveolatum breeds from June 22 to September 23.
Lixus scrobicollis breeds from July 12 to April 17 (following year).
Anthonomus squamosus breeds from August 11 to September 19.
Orthoris crotchii breeds from August 11 to September 19.
Lixus musculus breeds from August 11 to September 19.
Anthonomus disjunctus was found breeding October 11 to 14.

In the field at Dallas upon which release experiments were conducted, and in a series of five fields in various directions from Waco, it was found that the various species of parasites were exceedingly localized, indicating that the parasites were derived from the immediate vicinity.

On the Dallas field, by reference to the tables given in Section II, it will be noticed that Plat B with one small exception was the only plat in which Catolaccus was found; that Plat B was the only one from which Cerambycobius was bred; that Eurytoma was not found in Plat C, but was predominant on Plat E; and, finally, that Bracon was well distributed.

At Waco on all five fields *Bracon mellitor* was present in the proportion of 20 to 50 per cent. On the prairie land field, surrounded only by Ambrosia, Helianthus, and Xanthium, 41.6 per cent of the parasites were *Eurytoma tylodermatis*. On the other fields, which were on the bottoms, only one Eurytoma was taken to a field. *Catolaccus incertus* was present on the prairie land field and one bottom land field. Cerambycobius was present in all the bottom lands and very numerous, 58.3 per cent, in a field which had considerable *Solanum rostratum* about it; it was entirely absent on the prairie. The commonest plants on the bottoms were *Heterotheca subaxillaris*, *Croton* spp., *Solanum* spp., and Xanthium.

V. Conclusions and Prospects.

In conclusion the writer would say that there are a number of very important points obtained which indicate a possible natural control of the boll weevil. The actual combinations of conditions which bring about the instances of high parasitism can not be understood. It is very evident that the elements in the combination are relative moisture and light, plant response to weevil injury, abundance of other species of weevils in the immediate vicinity, and, finally, the ability for rapid adjustment to new host relations possessed by the local parasites.

Very high parasitism has been found, and it may therefore be expected again, perhaps locally, perhaps regionally. It may not necessarily be expected two years in succession at the same place, for a change in cultivation, an eradication of certain surrounding plants, or various other conditions might destroy the advantages previously gained. On the other hand, these same agencies in another locality might attain the opposite result.

Release of parasites in the open field on a small scale has been found to increase the rate of parasitization. This will be tried on a more extensive and better planned outline another year.

The abundance of hosts which have parasites in common with the weevil and the fact that parasitization takes place in the first generation give promise that the weevil's advance may be constantly disputed by the parasites.

BIBLIOGRAPHY.

ALDRICH, J. M.

1905. Catalogue of North American Diptera. <Smithsonian Misc. Coll., vol. 46, no. 1444, p. 427.

ASHMEAD, WILLIAM H.

1896. Descriptions of new parasitic Hymenoptera II. <Trans. Am. Ent. Soc., vol. 23, pp. 218, 219.

1902. A new Bruchophagus from Mexico. <Psyche, vol. 9, p. 324.

1902. Pequeña avispa parasita de picudo. <Boletín de la Comisión de Parasitología, vol. 1, no. 9, pp. 403–404.

BANKS, NATHAN.

1906. A revision of the Tyroglyphidæ of the United States. <U. S. Bur. Ent., tech. bul. 13, p. 17, pl. IV.

BARREDA, L. DE LA.

1904. El picudo del algodón. Salvacion de la riqueza de la frontera. <Comisión de Parasitología Agrícola, cir. 6, pp. 14–27.

CHITTENDEN, F. H.

1893a. The strawberry weevil. <Insect Life, vol. 5, pp. 167–186.

1893b. Observations on some hymenopterous parasites of Coleoptera. <Insect Life, vol. 5, p. 250.

1895. The potato-bud weevil (*Anthonomus nigrinus* Boh.). <Insect Life, vol. 7, pp. 350–352.

1897. The strawberry weevil (*Anthonomus signatus* Say). <U. S. Div. Ent., cir. 21.

1902. The potato stalk weevil. <U. S. Div. Ent., bul. 33, n. s., pp. 9–18.

COQUILLETT, D. W.

1897. Revision of the Tachinidæ of America north of Mexico, a family of parasitic two-winged insects. <U. S. Div. Ent., tech. bul. 7.

CRAWFORD, J. C.

1907a. New hymenopterous parasites of *Anthonomus grandis* Boh. <Can. Ent., vol. 39, pp. 133–134.

1907b. New North American Hymenoptera. <Journ. N. Y. Ent. Soc., vol. 15, no. 4, December, in press.

GILLETTE, C. P.

1890. Insects from Iowa. <Insect Life, vol. 2, pp. 280–281.

HINDS, W. E.

1907. Some factors in the natural control of the Mexican cotton boll weevil. <U. S. Bur. Ent., bul. 74. In press.

HOPKINS, A. D.

1892. Some bred West Virginia Braconidæ. <Insect Life, vol. 4, pp. 256–259.

HOWARD, L. O.

1897. The Mexican cotton boll weevil (*Anthonomus grandis* Boh.). <U. S. Div. Ent., cir. 18.

HUNTER, W. D.

1906. Medios para combatir el picudo del algodón. <Comisión de Parasitológía Agrícola, cir. 32, pp. 14, 30, 34, 39, fig. 7.

HUNTER, W. D., and W. E. HINDS.

1904. The Mexican cotton boll weevil parasites. <U. S. Bur. Ent., bul. 45, pp. 104–110.

1905. The Mexican cotton boll weevil parasites. <U. S. Bur. Ent., bul. 51, pp. 143–150.

MALLY, F. W.

1902. Report on the boll weevil. <Austin, Texas.

PIERCE, W. D.

1907a. Notes on the biology of certain weevils related to the cotton boll weevil. <U. S. Bur. Ent., bul. 63, Pt. II.

1907b. On the biologies of the Rhynchophora of North America. <Ann. Rept. Nebraska State Bd. Agr., 1906–1907, pp. 249–321.

1907c. Contributions to the knowledge of Rhynchophora. <Ent. News, vol. 18, pp. 356–363.

1907d. Studies of parasites of the cotton boll weevil. <U. S. Bur. Ent., bul. 73.

QUAINTANCE, A. L.

1906. The principal insect enemies of the peach. <U. S. Dept. Agr., yearbook 1905, p. 327.

RANGEL, A. F.

1901a. Segundo informe acerca del picudo del algodón (*Insanthonomus grandis* I. C. Cu.). <Boletín de la Comisión de Parasitología Agrícola, vol. 1, no. 5, pp. 171–176.

1901b. Tercer informe acerca del picudo del algodon. <Boletín de la Comisión de Parasitología Agrícola, vol. 1, no. 6, pp. 197–206.

1901c. Cuarto informe acerca del picudo del algodón (*Insanthonomus grandis* I. C. Cu.). <Boletín de la Comisión de Parasitología Agrícola, vol. 1, no. 7, pp. 245–261.

1901d. Quinto informe acerca del picudo del algodón. <Boletín de la Comisión de Parasitología Agrícola, vol. 1, no. 8, pp. 302–317.

RILEY, C. V., and L. O. HOWARD.

1890–91. Some of the bred parasitic Hymenoptera in the National Museum. <Insect Life, vol. 2, pp. 348–350; vol. 3, pp. 57–61, 151–158, 460–464; vol. 4, pp. 122–126.

TOWNSEND, C. H. TYLER.

1895. Report on the Mexican cotton boll weevil in Texas (*Anthonomus grandis* Boh.). <Insect Life, vol. 7. pp. 295–309.

INDEX.