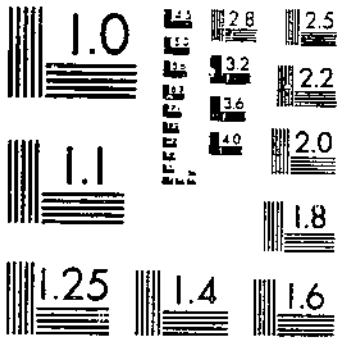
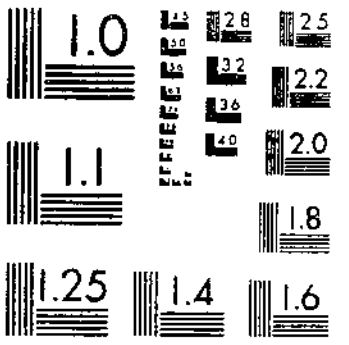
EXPERIMENTS WITH TRICHOGRAMMA MINUTUM RILEY AS A CONTROL OF THE

JAYNES, H. A. SYNUM, E. K.

START



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Technical Bulletin No. 743 • January 1941

UNITED STATES
DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

Experiments with Trichogramma minutum Riley as a Control of the Sugarcane Borer in Louisiana [1]

By H. A. JAYNES, *entomologist*, and E. K. BYNUM, *associate entomologist, Division of Cereal and Forage Insect Investigations, Bureau of Entomology and Plant Quarantine* [2]

CONTENTS

INTRODUCTION

The sugarcane borer (*Diatraea saccharalis* (F.)) causes considerable injury to sugarcane, corn, and rice in Louisiana, Texas, and Florida each year. Losses in sugarcane in Louisiana alone amount to from one million to several million dollars annually. The egg parasite *Trichogramma minutum* Riley is an important factor in control of this borer late in the season. Very few or no borer eggs are parasitized by this wasp early in the season, but parasitization increases as the season advances, and by harvest time nearly all borer eggs have become parasitized. Various efforts have been made to increase the usefulness of this parasite by increasing its numbers in the field early in the season.

[1] Received for publication April 17, 1940.

[2] The writers are indebted to W. H. Larrimer, in charge of the Division of Cereal and Forage Insect Investigations in 1933, to P. N. Annand, in charge of this Division from that year to September 1937, and to J. W. Ingram, in charge of sugarcane and rice insect investigations in the Division, for suggestions and criticism made during the course of these experiments and in the preparation of the manuscript. They hereby acknowledge the cooperation of the owners, managers, and overseers of the various plantations on which the experiments were conducted, and the assistance rendered by W. E. Haley, Leon J. Charpentier, Whitney Krepper, and others in making egg collections and infestation counts and in obtaining yield data.

A large number of publications deal with the different methods of rearing *Trichogramma minutum* and with experiments in mass liberations as a control for a great variety of insect pests. As there have been so many conflicting reports on the success of mass liberations of *Trichogramma* to control various insects, and since it has been stated that losses from the sugarcane borer in Louisiana could be greatly reduced by mass liberations of this parasite, it was decided to conduct a series of experiments in Louisiana to obtain further information on the value of this practice. The results of these experiments [3] are reported in this bulletin.

EARLY WORK WITH TRICHOGRAMMA

In 1921 Cleare (*3*),[4] in British Guiana, first began the breeding of *Trichogramma* on a large scale for field liberations in sugarcane fields. He stored borer-infested shoots ("dead hearts") in an insectary and reared *Trichogramma* adults from the eggs deposited by the moths emerging from these shoots. As many as 35,000 *Trichogramma* per day were liberated during a period of 3 months on one sugarcane estate. This practice was regarded with much favor at first, but Cleare (*4*) later stated that more recent investigations by Myers had shown the inadequacy of this method of control.

In 1926 Flanders (*5*) experimented with laboratory rearing of *Trichogramma* on various host eggs and found the Angoumois grain moth (*Sitotroga cerealella* (Oliv.)) to be well adapted to quantity production of *Trichogramma*.

Hinds and Spencer (*8, 9*) were the first to apply Flanders' methods of rearing *Trichogramma* on eggs of *Sitotroga* to the control of the sugarcane borer by mass liberations of the parasite. They reported a marked increase in parasitization in 1927, 1928, and 1929 in canefields where *Trichogramma* had been released and reported borer control in certain fields on one plantation in 1929.

After six seasons' work in experimental control of the sugarcane borer by *Trichogramma* liberations, Hinds, Osterberger, and Dugas (*6*) reported as follows:

> *Trichogramma* colonization tests as made in fields of corn and sugar cane in Louisiana during the seasons of 1927 to 1932 have shown consistently beneficial results in the rapid increase following in the rate and proportion of borer eggs destroyed. They have shown consistent, and regularly proportional, decreases in borer damage as measured by the percentages of joints bored, the number of emergence holes found and the moth population produced per acre. They have shown regularly a very substantial increase in the number of millable stalks produced, amounting to about 6000 per acre. The corresponding increase in the weight of millable cane has amounted to more than three tons per acre. With this there has been found an average increase of over 20 lbs. of sugar per ton of cane produced in protected areas. This does not mean complete control of the borer and never will—but it appears to show one practicable, easily usable and very dependable and profitable method which may be used in decreasing borer damage in Louisiana.

Tucker (*16*), in 1935, reporting on 6 years' work with *Trichogramma* releases in Barbados as a control for *Diatraea saccharalis*, stated that

> * * * Whilst an adequate statistical proof of increased general and average-parasitism may not have been obtained, there is a definite indication that the

[3] In 1933 the experiments were conducted under the direction of H. A. Jaynes from the Houma laboratory. In 1934 and 1935 the Jeanerette and Houma experiments were conducted as separate units, with Mr. Jaynes responsible for the experiments at Jeanerette and E. K. Bynum for those at Houma. During these 3 years the experiments were under the direction of J. W. Ingram, in charge of sugarcane and rice insect investigations, who was responsible for outlining and coordinating the work.

[4] Italic figures in parentheses refer to Literature Cited, p. 42.

early mass releases of parasites each year achieve their purpose of increasing this mortality in a manner which results in a measurable decrease in the number of "effective borers" which survived over the period of liberation and therefore of the final damage to the crop.

Smyth (*15*), reporting on the technique in the mass production of *Trichogramma* used to control the cane borer in Peru, says,

> Significant is the fact that as a result of mass colonizations of *Trichogramma* wasps reared by this technique, borer damage was so reduced that the purity and sucrose of the cane (and hence the sugar content) showed a very considerable increase, in a large series of fields colonized with parasites, over those registered in other fields of the same plantation not so colonized.

Mass liberations of *Trichogramma* have been tried as a control for insects other than the sugarcane borer. Peterson (*12*), in 1930, in experimenting with *Trichogramma* as a control for the oriental fruit moth (*Grapholitha molesta* (Busck)) reported

> Preliminary field tests in a peach orchard indicate that small liberations of from 300 to 1,000 adults per tree are not sufficient to produce parasitism among eggs in adjacent trees.

Allen and Warren (*1*), working with the same insect, reported in 1932, at the end of 2 years of investigations, that the increased production of fruit did not justify the added expense. The releases were made at the rate of 55,000 parasites per acre during each of the two seasons. Schread and Garman (*14*), also experimenting with the release of *Trichogramma* as a control for the oriental fruit moth, reported in 1933 as follows:

> The average percentage parasitism in 1931 in three orchards where no *Trichogramma* were liberated was 23; in those orchards where they were liberated it was 45 percent. * * * Observations and field counts indicated that high *Trichogramma* parasitism was correlated with reduced infestation, but the reduction was not enough in some cases to be called commercial control.

List and Davis (*11*) conducted experiments for 2 years with *Trichogramma minutum* as a control for the codling moth (*Carpocapsa pomonella* (L.)) and in 1932 made the following statement regarding the results of their experiments:

> They indicate that during seasons of high natural parasitism little is accomplished by either mass liberations or by colonization of *Trichogramma*. During seasons of low natural parasitism liberations can be responsible for a pronounced parasitism but in no case has this been sufficient to show a marked control of the codling moth as indicated by fruit examinations.

Schread (*13*) carried on some cooperative experiments with A. W. Morrill and the Associated Seed Growers of Milford to determine the value of releasing *Trichogramma* for the control of the European corn borer (*Pyrausta nubilalis* (Hbn.)) and reported, after parasite release at the rate of 10,000, 20,000, and 30,000 per acre, that

> Data accumulated throughout the season were not significant from the standpoint of colonization. The average parasitism in the adjacent areas was slightly higher than in the colonized areas, whereas during the second brood the results were the reverse. In the check plots the average parasitism during the second brood was approximately five times as great as found in the colonized areas.

Clausen (*2*) made the following statement in 1935 about the liberation of *Trichogramma* as a control for insect pests:

> In recent years efforts have been made to extend the usefulness of this parasite by rearing the species in enormous numbers upon grain moth eggs and liberating them in the infested fields and orchards early in the season. This has been tried on a number of important pests of field crops and orchard trees, but the results

thus far have not been conclusive. This work is still in the experimental stage, and at present it is not recommended to growers as a field practice.

EXPERIMENTS CONDUCTED IN CONNECTION WITH THE GENERAL PROBLEM

In investigating the value of releases of *Trichogramma minutum* it was found desirable to obtain all information that would be useful in interpreting the data or that would shed additional light on the problem. The results of these related investigations are given first.

Overwintering of Trichogramma

Very little is known about how or where *Trichogramma minutum* passes the winter months in Louisiana. No *Diatraea* eggs are available from harvest time in the fall until the moths emerge from the overwintered borer larvae in the spring, a period of from 3 to 5 months. Parasitized eggs of *Diatraea* that have been collected in the fall and kept under the temperatures prevailing at the time have always produced adults of *Trichogramma* within a comparatively short period. It seems unlikely that *Trichogramma* adults hibernate from the fall to the spring, as there are days and periods of days during the winter warm enough for adult activity. It seems reasonable to assume that mating and egg deposition take place in the field during these warm days, as is the case in the laboratory.

In an attempt to determine what environments are most conducive to *Trichogramma* survival over the winter, *Sitotroga* eggs were placed in the field from the latter part of January through to the middle of May 1933, to determine whether they would be parasitized. From 100 to 300 or more eggs were pasted on a small piece of cardboard. These cardboards were placed in a field in sets of 8, each card being fastened to a small stake and protected from the direct sunlight by a shingle attached to the stake. They were put out every 2 weeks, and were placed in 4 fields of cane, 1 alfalfa field, 2 cabbage fields, and 1 turnip field, 1 wooded swamp, and 2 cornerbs. None of these eggs ever showed signs of parasitization.

Searches were made during the winter for eggs of various insects, but none of those found had been paratitized by *Trichogramma*, although a live adult of *Trichogramma* was taken on a mustard leaf in a small plot at the Houma laboratory on February 5, 1934.

During the third week in May 1934, 16 stakes were so placed that 1 was at the edge of a wood, then 1 every 100 feet along rows of corn up to 1,000 feet, then 1 stake every 200 feet along a row of cane, making the last stake 2,000 feet from the woods. Cardboards containing bagworm eggs were placed on these stakes, but none were parasitized.

It was not known what species of eggs might be available in nature as host material for *Trichogramma* during the winter and early in the spring. As it was very difficult to locate eggs in any number that might be subject to parasitization, a few bait traps were used each year during certain periods of the winter and early spring months to obtain a collection of the various moths that might be laying eggs that would possibly serve as hosts. A solution of corn sirup and water (1 to 9 parts) with yeast was used as a bait. On March 20, 1933, 10 traps were placed 50 feet apart along a ditch in a canefield

at Houma. These traps were removed on April 30. During this period only 185 moths were caught.

On February 22, 1934, 6 traps were placed around an old garden patch that was somewhat overgrown with weeds and brush, near an old oak tree at Jeanerette. Four other traps were placed between a canefield and a pecan orchard at the same time. During the first 15 days 493 moths were caught. A new solution was placed in them on March 15, but only 110 moths were taken during the next 15 days. The traps near the old garden patch caught many more moths than those alongside the canefield. Eggs were obtained from 76 of the moths, and adults of *Trichogramma minutum* were put with some of these eggs. Eggs from 22 different individuals were parasitized.

Bait traps were again set out at Jeanerette on January 12, 1935. Five of these traps were placed 100 feet apart along a ditch between two cuts of stubble cane on Albania Plantation. The field was surrounded by other canefields. The other five traps were placed in the woods in back of Albania Plantation. The first trap was about 230 feet in from the edge of the woods and the others were at 100-foot intervals.

Collections of moths were made for 5 days. The traps were refilled and collections were made at two later periods. The results of the collections are listed in table 1.

TABLE I.—*Bait-trap collection of moths (all species) at Jeanerette, La., 1935*

Collection period	Moths collected in—	
	Canefield	Woods
	Number	*Number*
Jan. 13–17	171	62
Jan. 27–Feb. 2	9	15
Feb. 12–16	187	229
Total	367	306

Out of the 673 moths collected in 1935, 129 females deposited eggs in the laboratory. Eighty of these females were from the traps in the canefield. By exposing these eggs to *Trichogramma*, parasitization was obtained on eggs from 53 different individuals. Eggs of 33 of 49 females collected in the woods were also parasitized.

Since the moths have not been identified, the number of species collected, which species deposit eggs that are readily parasitized, and which deposit eggs not readily parasitized, are not yet known. Certain species deposited a layer of hairs over the egg cluster, and these eggs were seldom parasitized by *Trichogramma*.

It may be noted that there was a considerable difference in the number of moths collected during the three periods of exposure in 1935. It is probable that this difference was due, at least in part, to variations in temperature. The first killing frosts occurred on December 11 and 12, when the minimum temperatures were 26° and 21° F., respectively. This temperature no doubt killed some of the adult moths present, but it did not kill many of the larvae and pupae, as a fair number of moths were collected from January 13 to 17, a month after the freeze. The second cold spell came between January 22 and 25, when a minimum temperature of 19° was reached. This low temperature probably

killed a number of the moths present, and very few were collected from January 27 to February 2. Moths either were few or else not active, as the temperature during this period was lower than during either of the two other collection periods. By the time of the third collection, however, February 12–16, moths were very abundant.

Owing to the greater protection offered moths, it was thought that more eggs might be available for parasitization in the woods during the winter than in the more exposed canefields. This may be the case, as the moths may go to the woods to deposit their eggs, but the moths were apparently as abundant in the canefields as in the woods. These collections indicate very clearly that a number of lepidopterous eggs are being laid during the winter and early spring months that could serve as host eggs for *Trichogramma minutum*.

Dispersal of Trichogramma minutum

Experiments to determine the natural spread of *Trichogramma* in canefields were carried on in 1933 and 1934, the first year at Houma and the second at Jeanerette.

In 1933 2 groups of 56 stakes each were arranged with 8 at 25 feet from the center and 16 each at 50, 75, and 100 feet from the center. Cards of fresh *Sitotroga* eggs were placed at a height of 1½ feet on all the stakes, and additional cards of *Sitotroga* eggs were placed at a height of 5½ feet on 8 of the stakes in each group at the cardinal points of the compass. Reference to cards on these 8 stakes will have the additional notation in parentheses as to whether the high or low card is referred to. *Trichogramma* adults were released in the center of 1 group of stakes. The other group, which was 740 feet away (center to center) served as a check.

As before, the cards were protected from the sun by a small shingle. Ten sets of cards were used during the period of 13 days on both the release and the check group of stakes. Some 75,000 *Trichogramma* adults were released at the center of 1 group of stakes on April 11, just after the first set of cards had been placed on the stakes at 8 a. m. There was a fairly strong wind from the NNW. The cards were collected the next morning and later showed parasitization to have occurred at 25 feet SE.; at 50 feet SE., SSE., and NNW.; and at 75 feet SSE. There was no parasitization on the cards from the check group. The second set of cards from the release group showed no signs of parasitization, but in the check group, which was 740 feet directly east of the release group, parasitization occurred at 25 feet NW. and 100 feet SE. from the center of the check group of stakes.

On April 13, 80,000 more *Trichogramma* were released. Cards put out just before this release and left for 48 hours showed parasitization at the following points: 25 feet NW., W., SE., and NE.; 50 feet at WNW., N. (low), E. (low), and NE. No parasitization appeared in the check group. There was a rainfall of 0.45 inch between April 13 and 14. Cards for the next 48 hours showed parasitization at 25 feet N. and 50 feet E. (low). No parasitization developed in the check group for this set or in any of the later sets.

No further parasitization was obtained in the release group until the last set, exposed from 9 a. m., April 23, to 9 a. m., April 24, when parasitization occurred at 50 feet E. (high), W. (high), and WSW. The weather during this period was not favorable, but the experiment

showed that the parasites spread at least 50 to 75 feet within a few hours after release, apparently by drifting with the wind, which was shifting.

In 1934 2 groups of 40 stakes were arranged with 8 each at 25, 50, and 75 feet from the center and 16 at 100 feet from the center. Cards were placed at a height of 1½ feet on all stakes and additional ones, as in 1933, were placed at a height of 5½ feet on 8 of them. Cards containing fresh bagworm eggs were placed on these stakes, and were protected from the sun by small shingles. Six sets of cards were used during the period of 9 days. The center of the check stakes was 1,200 feet west of the point where the releases were made. Approximately 40,000 *Trichogramma* adults were released on April 26, and another 40,000 were released on April 27 at the center of the test group.

No parasitization was obtained on any of the cards of the six sets placed on the check stakes. No parasitization was obtained from the first set in the release area, which was exposed from April 26 to 27. In the second set parasitization was obtained on seven different cards, as follows: At 25 feet SE.; at 50 feet SE., S. (low), N. (high), and N. (low); and at 100 feet E. (low) and E. (high). On April 26 the wind was first from the southeast, then later a fairly strong wind blew from directly south. On April 27 a slight breeze was from the southwest. On April 28 there was a fair breeze from the north. In the third set parasitization was obtained at 25 feet SE. and at 50 feet S. (high). In the fourth set parasitization occurred only at 25 feet S., and in the fifth set only at 50 feet S. (high). A large number of *Trichogramma* were still on the center stake on May 1. Parasitization was obtained in the sixth set on five cards, all at 50 feet, E. (high), SE., S. (high), S. (low), and N. (low).

On several of the cards all the eggs had been eaten by spiders, ants, beetles, and other pests, although all the stakes had a good band of a sticky material around them just above the surface of the ground. No rain fell during this period except for a slight sprinkle on May 2, when the sixth set of cards was being put out.

It may be noted that parasitization was obtained as far as 100 feet from the release point within 48 hours after the first release of *Trichogramma*. This agrees very closely with the results of the previous year, when parasitization occurred at 25, 50, and 75 feet within the first 24 hours after release.

These experiments were conducted in April, rather than later in the season, to minimize interference by parasites already present in the field. At the time parasites are being released for control purposes the cane is higher, and dispersal may vary from that found at these earlier dates.

Length of Time Parasitized and Nonparasitized Egg Clusters of the Sugarcane Borer Remain on Plants

To determine the relative length of time parasitized and nonparasitized egg clusters remain on plants, and thereby the reliability of counts including emerged or hatched egg clusters, 168 freshly laid borer egg clusters were located and marked on corn and cane at Jeanerette between July 12 and 19, 1934. The majority of these were on corn. These clusters were examined as often as possible until August 14, when other work prevented further observations. One

hundred and sixty-four clusters, or part clusters, that were not parasitized remained on the leaves an average of 23.4 days. Fifty-seven clusters, or part clusters, that were parasitized remained on the leaves an average of 21.4 days. It appears from these observations that there is little difference between the length of adherence to leaves of parasitized and nonparasitized egg clusters. If the observations had not been interrupted, results at variance from these might have been obtained.

Relation of Actually Bored Joints to Joints Showing Borer Injury Externally

Investigators in this and in other countries have differed on the best methods for determining borer injury to sugarcane. Some have used only the percentage of stalks bored, and have not made counts of joints bored. Since the reliability of joint counts as a measure of borer injury was unknown, investigations were conducted to determine their dependability.

During the 3 harvest seasons of 1933–35, 200 stalks per plot were usually examined to determine the number of bored stalks and bored joints and thereby the relative damage in colonized, buffer, and check plots. Of these 200 stalks examined, 50 stalks per plot were split and examined for internal borer injury in each experiment except in those in Jeanerette in 1935. In all, 6,235 stalks were split open and a record was made of the total joints bored and of those that showed this damage externally. Of the 6,235 stalks split, 5,567 were bored, and the record of the joints bored externally and internally is shown in table 2. It was thought that in some cases a borer might enter a stalk and bore through several joints and the stalk might show externally only 1 or 2 bored joints. It will be seen from table 2 that of all the stalks examined only 1 showed a count of 5 joints more bored internally than showed externally. There were 2 stalks showing 4 more bored internally than showed externally, and the usual limit was not more than 3 and this in a very small proportion.

Table 2.—*Number of joints of sugarcane classified with respect to both joints bored externally and joints bored internally by the sugarcane borer, Louisiana, 1933–35*

Number of joints bored externally	Stalks having indicated number of joints bored internally														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number
1	735	98	10												843
2		832	248	24	7										1,111
3			790	235	63	8	1								1,097
4				651	173	42	8								874
5					472	114	33	7	1						627
6						324	70	24	4						422
7							197	50	14	1					262
8								107	33	8	3		1		152
9									77	16	1	2			96
10										35	9	2	1		47
11											14	1	2	1	18
12												7	2		9
13													2	2	4
14														5	5
Total	735	930	1,048	910	715	488	309	188	129	60	27	12	8	8	5,567

To ascertain the degree of association between externally and internally bored joints the coefficient of correlation was obtained and found to be 0.97 with a probable error of 0.0059. This correlation was based on the total of all stalks examined, no consideration being given to variation due to variety and to year of crop.

With the knowledge of this high degree of correlation, considerable time can be saved in making infestation counts by substituting external for internal examinations and it becomes unnecessary to destroy a large number of stalks just before harvesting.

The data obtained by splitting the stalks have been arranged in table 3 to indicate the number of joints showing boring externally, the total number of joints bored internally, the number of stalks bored, the number of joints bored internally per stalk, and the ratio of the number of joints bored internally to the number of joints showing boring externally.

TABLE 3.—*Ratio of joints of sugarcane showing externally and internally the boring of the sugarcane borer, Louisiana, 1933–35*

Joints showing boring externally (number)	Total joints bored internally	Stalks bored	Joints bored internally per stalk	Ratio of the number of joints bored internally to the number of joints bored externally
	Number	*Number*	*Number*	
14	70	5	14.000	1.0000
13	54	4	13.500	1.0385
12	110	9	12.222	1.0185
11	206	18	11.444	1.0404
10	486	47	10.340	1.0340
9	888	96	9.250	1.0278
8	1,279	152	8.414	1.0518
7	1,915	262	7.309	1.0441
6	2,662	422	6.308	1.0513
5	3,340	627	5.327	1.0654
4	3,777	874	4.322	1.0805
3	3,680	1,097	3.355	1.1183
2	2,539	1,111	2.285	1.1425
1	961	843	1.140	1.1400
Total	21,967	5,567		

RELATION OF RATE OF PARASITIZATION TO HOST DENSITY

In the early parts of the three seasons the parasitization ranged from 0 to 100 percent, while toward the latter part of the season it was always fairly high.

The eggs collected from July 18 to September 28, 1933, have been grouped in table 4 according to the number of eggs found per unit hour of search. In comparing the percentage of parasitization with the average number of eggs found per hour it will be noted that parasitization rises very rapidly until some 400 eggs per hour are found. After that there is a slight rise until when from 800 to 2,800 eggs are found per hour there is very little difference in the percentage of parasitization.

To ascertain whether there was a possible correlation between the percentage of parasitization and the host density, a correlation table was made in which all eggs collected on an hourly basis, between July 2 and September 28, in the 3 years were plotted. The class groups for the eggs were 1–50, 51–100, etc., up to 4,701–4,750 and

included 522 separate hourly collections. The class groups for the percentage of parasitization were 0.0–5.0, 6–10, 11–15, etc. The coefficient of correlation was found to be 0.59 with a probable error of ±0.019. This shows that there is a decided correlation between percentage of parasitization and host density.

TABLE 4.—*Rate of parasitization of sugarcane borer eggs by Trichogramma minutum as related to the number found per unit hour of search in Louisiana, 1933*

Eggs found per hour July 18 to Sept. 28 (number)	Total hour units	Total eggs	Total eggs parasitized	Average parasitization	Average for eggs per unit hour
	Number	*Number*	*Number*	*Percent*	*Number*
1 to 50	23	581	18	3.1	25.3
51 to 100	19	1,381	377	27.3	72.7
101 to 150	14	1,873	585	31.2	133.8
151 to 200	9	1,518	1,081	71.2	168.7
201 to 400	22	6,352	4,289	67.5	288.7
401 to 600	12	6,050	5,181	85.6	504.2
601 to 800	15	10,283	8,619	84.0	684.2
801 to 1,000	6	5,240	4,805	91.7	873.3
1,001 to 1,200	2	2,140	2,065	96.5	1,070.0
1,201 to 1,400	4	5,138	4,561	88.8	1,284.5
1,401 to 1,600	4	5,892	5,391	91.5	1,473.0
1,601 to 1,800	1	1,795	1,643	91.5	1,795.0
1,801 to 2,000	1	1,990	1,667	83.8	1,990.0
2,001 to 2,200	3	6,323	6,042	95.6	2,107.6
2,201 to 2,400	1	2,260	2,061	91.2	2,260.0
2,401 to 2,600	0				
2,601 to 2,800	1	2,769	2,652	95.8	2,769.0

In collecting borer egg clusters in 1934 and 1935 each unit of collecting was divided into 10-minute periods, and a record was kept both of the number of clusters and the percentage of parasitization of the eggs in the various 10-minute collecting periods. To determine the reliability of the egg collections made in connection with the *Trichogramma* experiments, a statistical analysis was made of the 1934 data from the Houma area with the assistance of George Arceneaux, agronomist of the Bureau of Plant Industry. This study showed that data on parasitism obtained by egg collections prior to August were of doubtful reliability, and that only the data obtained during August and September were dependable. During the spring and early summer months the primary purpose in making egg collections was to determine the prevalence of borer eggs so as to time parasite releases properly. Data on egg collections in 1934 are given in table 5.

TABLE 5.—*Average numbers of egg clusters of the sugarcane borer collected per 10-minute period at different dates during 1934 at Houma, La.*

Collection dates	10-minute periods	Egg clusters collected	Average for clusters per 10-minute period
	Number	*Number*	*Number*
Apr. 15–30	108	40	0.37
May 10–25	72	6	.08
June 1–15	153	81	.53
June 16–30	50	86	1.7
July 1–15	90	244	2.7
July 16–31	108	293	2.7
Aug. 1–31	198	920	4.6
Sept. 1–30	180	2,310	12.8
Total and average	959	3,980	4.15

EXPERIMENTS WITH TRICHOGRAMMA MINUTUM IN THE CONTROL OF THE SUGARCANE BORER

During the seasons of 1933, 1934, and 1935 experiments were conducted by the authors in Louisiana to determine the efficacy of mass releases of the egg parasite *Trichogramma minutum* for the control of the sugarcane borer in sugarcane. A preliminary report (*10*) covering results of these experiments has already been published.

Nine experiments were carried on in cooperation with the Louisiana Agricultural Experiment Station in 1934 and 1935. In 1934 two of these were located on Raceland Plantation, Raceland, La., and in 1935 four were conducted on Reserve Plantation, Reserve, La., and three on Shadyside Plantation at Centerville, La. Parasite releases were made jointly in these experiments, the parasites being supplied by either the State or Bureau representatives or in some cases by both. The Bureau representatives made egg collections, infestation counts, and small-mill analyses of the cane separate from those made by the State. The harvest records and factory analyses of these experiments were usually obtained jointly. A Bureau representative was present during the harvesting for all experiments. These cooperative experiments are designated in all the tables by the letter c preceding the experiment number.

Selection of Experimental Fields

In 1933, *Trichogramma* adults were released on 17 plots of sugarcane, and 15 comparable plots were used as checks, with 10 intervening plots serving as buffers. These plots ranged in size from 2.73 to 26.00 acres. In selecting the plots care was taken to see that the stand and soil of the colonized plot and corresponding check were as nearly similar as possible. Practically all the experiments were conducted with varieties of sugarcane most subject to heavy borer injury and were located in the vicinity of Houma, Franklin, or Plaquemine where the injury was usually above the average.

Ten experiments were carried on in the Jeanerette area and 10 in the Houma area in 1934, and in 1935 11 experiments were completed in the Houma area and 9 in the Jeanerette area. Each experiment covered an area on which parasites were colonized, and an untreated check area of approximately the same size, with an intervening area, usually larger, called the buffer. Smaller plots were used than in 1933. In 1934 the colonized areas ranged from 2.53 to 7.84 acres, the buffer areas from 3.14 to 9.57 acres, and the check areas from 2.34 to 7.18 acres. In 1935 the colonized areas ranged from 1.09 to 6.87 acres, the buffer areas from 2.31 to 8.64 acres, and the check areas from 1.09 to 4.97 acres.

Still greater care was taken during these years in selecting the areas, as all experimental plots were checked for uniformity of soil type by A. M. O'Neal, associate soil technologist of the Bureau of Plant Industry, and were approved by him as comparable for experimental purposes. All experimental areas were also checked with plantation managers, scientific advisors for the plantations, and overseers for similarity of past treatments and equality of past yields. In 1935, as a further check on the similarity of the colonized, buffer, and check plots of each experiment, measurements of gaps in the rows were made. All gaps of over 18 inches were recorded. Usually

100 feet of row in 20 scattered locations in each of the colonized, buffer, and check plots, or 6,000 feet for each experiment, was examined and measured for gaps. The gaps were recorded in groups of 6 inches above the 18-inch gap. Those gaps measuring between 18 and 24 inches would fall in group 1, with an average of 1.75 feet; those between 24 and 30 inches in group 2, with an average of 2.25 feet; and so on. From the total of the gap measurements and the total number of feet examined, the percentage of gaps was obtained. Gap counts were made in all canefields that were being considered for use in the *Trichogramma* experiments.

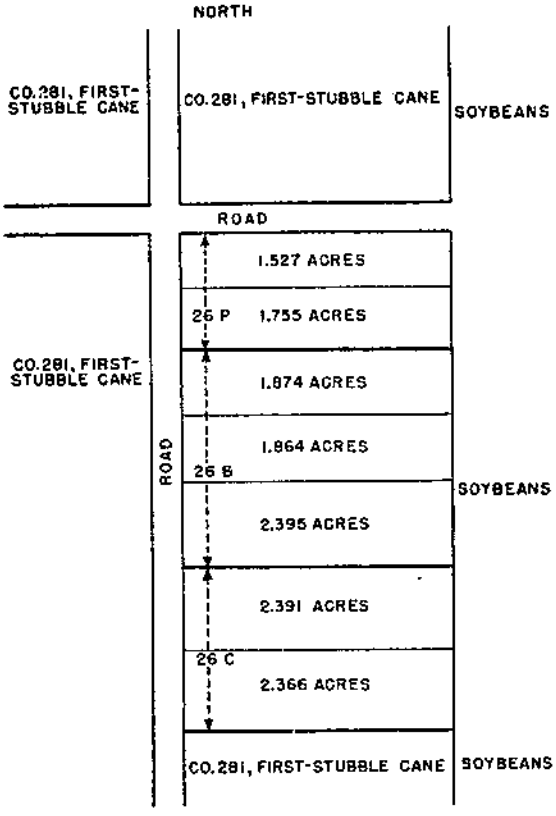


FIGURE 1.—Typical lay-out of a *Trichogramma* experiment in a field of Co. 281, first-stubble cane, as conducted during 1934 and 1935 at New Hope Plantation, Lafourche Parish, La.: 26P represents the two cuts on which the parasites were released in experiment 26; 26B, the corresponding buffer area; 26C, the check.

Nearly twice as many fields as would be used for the experiments were tentatively selected early each season. During subsequent examinations some fields had to be eliminated because of an uneven stand, others because of exceptionally light infestations of borers, and others because gap measurements indicated that the stand was not uniform. The study of a large number of fields and the checking of the progress of cane growth and borer infestation from the first of the season to the time when they were ready for parasites gave a better opportunity to select fields that were comparable for use in the experiments than could be had by waiting until moths of the second generation were laying eggs and selecting the plots then or even later. Fields were selected where the borers were usually most numerous.

The immediate environments of the fields used were also considered, care being taken to see that where possible the colonized and check areas were bordered by a similar kind of crop. A diagram showing the plan of an experiment is given in figure 1. This is typical of the experimental fields used in 1934 and 1935. In some cases, however,

the colonized plot or the check plot consisted of only one cut instead of two. The buffer ranged from two to five cuts, depending on the size of the field available.

Release of Parasites

A close check was kept on the egg deposition in cane and in the earliest corn to ascertain when parasites should be released. When dead hearts of cane and stalks of corn were split, especially those that were stunted, pupal skins found gave an indication of the number of moths that had emerged and were depositing eggs for the second generation. The parasites were released when three or more clusters of unhatched second-generation eggs could be found in an hour's search.

In some fields three or more batches of unhatched eggs, laid by moths from overwintering borers, could be found in an hour during April, but there was a period in May or early in June when there were very few eggs in the field. It had been recommended that parasites should not be released until borer eggs from the second generation began to appear, after which there would be a continuous supply of eggs throughout the remainder of the season.

It has also been stated that one release at the rate of about 5,000 per acre may be sufficient for the season if rightly timed, but that colonizations made after August 1 should be at the rate of 10,000 per acre. (7).

In 1933 parasites were released at the rate of approximately 13,000 per acre in cane and, in addition, at the rate of 9,000 per acre in corn when this was adjacent to the colonized cane plot. The first releases were made between June 10 and 17 in all fields except one. It had been planned to make 2 additional similar releases 10 days to 2 weeks later, but this was not done as there was a decided decrease in the number of borer eggs during the last of June and the first of July, due, no doubt, to the occurrence of a long dry spell over most of the cane section. Borer eggs began to increase in numbers again late in July and in the first part of August, and further releases were made in all fields in August, and some were made as late as September, but only because parasites were available. Approximately 2,404,000 parasites were released in 173 acres of cane, and 722,000 in 80 acres of corn. Two experiments were carried on in corn to observe the increase in percentage of parasitization and possible difference in yield. Other cornfields in which parasites were released bordered some of the colonized plots of cane. In table 6 are shown the dates and approximate rates of the releases made in 1933.

In 1934 the first release of parasites in the Houma area was made on June 14 and the last of the 10 experiments received parasites on June 25. On June 16 a hurricane swept through the Jeanerette region and whipped and tore most of the corn and cane leaves into long, thin shreds, destroying practically all the borer eggs present, as only fresh eggs, laid after the storm, could afterward be found. Since this reduced the available supply of host eggs, parasite releases there were considerably delayed, and in only 2 plots were parasites released in June—these on June 20 and 23. Only the edge of the storm reached Houma, and the borer eggs in that locality were not destroyed.

TABLE 6.—*Releases of Trichogramma minutum in sugarcane and corn in Louisiana, 1933*

IN SUGARCANE

Plot No.	Size of plot	Parasites released on dates specified						Total released	Released per acre
		June 10–17	July 4–8	Aug. 5–10	Aug. 14–19	Aug. 24–29	Sept. 4–6		
	Acres	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
20	19.78	80,200		71,000		65,000	160,000	376,200	19,019
19	8.54	14,400		25,000	37,000	53,000	40,000	169,400	19,836
9	3.50			16,000		22,000	40,000	78,000	22,286
109	18.28	74,500			95,000	70,000		239,500	13,102
127	11.00	39,500		40,000		30,000		109,500	9,954
113	15.00	40,000		60,000		60,000		160,000	10,667
108	26.00	72,500			100,000	70,000		242,500	9,327
106	19.00	75,000			50,000	52,000		177,000	9,316
118	7.00	36,500	30,375	37,000		25,000		128,875	18,411
103	11.00	43,000			53,000	35,000		131,000	11,909
13	8.01	14,400		28,000		46,000	75,000	163,400	20,400
12	7.89	19,900		26,000	38,000	46,000	25,000	154,900	19,632
1	2.73	12,000		9,000	14,000	17,000		52,000	19,048
4	7.49	30,000		16,000	22,000	30,000		98,000	13,218
8	8.24	30,000		26,000	37,000	30,000		123,000	14,927
Total	173.46	581,900	30,375	354,000	447,000	651,000	340,000	2,404,275	13,860

IN CORN

123	22.0	30,000	130,625					160,625	7,301
129–130	10.0	27,000	73,000					100,000	10,000
112	15.0	30,000	67,000					97,000	6,467
117	18.0	40,000	125,500					165,500	9,194
102	8.0	39,000	92,000					131,000	16,375
Raceland	3.0		28,000					28,000	9,333
Pecan tree	4.0		40,000					40,000	10,000
Total	80.0	166,000	556,125					722,125	9,027

During July and August additional parasites were released in the 10 plots near Houma. More parasites were released in the middle and last part of July in the 2 plots at Jeanerette that received parasites in June, and parasites were released the last of July and the first of August in the remaining 8 plots. Approximately 15,500 *Trichogramma* were released per acre in the Jeanerette area and 18,500 per acre in the Houma area. It may be noted that the numbers of parasites released were considerably larger than the 5,000 per acre in June, or 10,000 per acre if the release is delayed until later, usually recommended by commercial and State agencies. Approximately 1,390,000 parasites were released in 82 acres of cane and a few additional thousand in corn adjoining some of the cane plots. In table 7 are given the approximate numbers of *Trichogramma* released per acre in 1934.

In some of the tables and in many places in the text the letters P, B, and C have been used to designate, respectively, with the experiment numbers, the colonized (parasitized), buffer, and check plots. As previously stated, a prefixed letter c denotes a cooperative experiment.

TABLE 7.—*Releases of Trichogramma minutum in sugarcane in Louisiana*

JEANERETTE RELEASES, 1934

Plot No.	Size of plot	Parasites released on dates specified				Total released	Released per acre
		June 6–23	July 13–31	Aug. 2–5	Aug. 6–9		
	Acres	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
1-P	7.84				105,000	105,000	13,393
2-P	4.15			50,000		50,000	12,048
3-P	3.82	10,000	15,000	20,000		45,000	11,780
4-P	3.64		18,000	30,000	21,000	69,000	18,956
5-P	1.85	10,000	38,000			48,000	25,946
6-P	3.35			49,000		49,000	14,627
7-P	6.14			73,000	18,000	91,000	14,821
8-P	6.90		33,000	37,000	34,000	104,000	15,072
9-P	2.97		48,000			48,000	16,161
10-P	2.53		58,000			58,000	22,925
Total	43.19	20,000	210,000	259,000	178,000	667,000	15,443

HOUMA RELEASES, 1934

Plot No.	Size of plot	Parasites released on dates specified				Total released	Released per acre
		June 14–28	July 23–31	Aug. 1	Aug. 16–18		
	Acres	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
c1-P	5.35	64,000		32,000		96,000	17,944
c2-P	3.19	29,500		30,200		59,700	18,715
3-P	3.56	53,000			38,700	91,700	25,758
4-P	4.96	49,700			31,500	81,200	16,371
5-P	3.15	53,200	6,000		10,800	70,000	22,222
6-P	4.58	70,200	9,800		16,250	96,250	21,015
7-P	3.35	19,600	24,150		11,600	54,750	16,343
8-P	3.24	24,100	5,700	17,760	5,125	52,685	16,261
9-P	3.37	21,300	5,900	13,332	10,250	50,782	15,069
10-P	4.20	34,500	24,150		11,700	70,350	16,514
Total	39.91	418,500	75,700	93,292	135,925	723,417	18,549

JEANERETTE RELEASES, 1935

Plot No.	Size of plot	Parasites released on dates specified				Total released	Released per acre
		June 16–19	July 26–30	Aug. 7	Aug. 13		
	Acres	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
3-P	4.38			44,325	11,250	55,575	12,688
4-P	3.99	12,600	40,725		11,250	64,575	16,184
7-P	2.98		36,450			36,450	12,314
8-P	4.85			46,887	16,875	63,562	13,869
10-P	2.86		29,025			29,025	10,149
c13-P	2.74	16,000	29,250			45,250	16,515
14-P	2.99		36,900			36,900	12,341
c19-P	2.73	17,000	27,337			44,337	16,421
c20-P	2.94	16,000	29,025			45,025	15,315
Total	30.24	61,600	28,712	91,012	39,375	420,699	13,911

TABLE 7.—*Releases of Trichogramma minutum in sugarcane in Louisiana*—Con.

HOUMA RELEASES, 1935

Plot No.	Size of plot	Parasites released on dates specified				Total released	Released per acre
		June 14	July 27	Aug. 8	Aug. 13–14		
	Acres	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
21–P	1.52	14,250	27,250	.....	21,000	62,500	41,118
22–P	3.19	23,250	42,000	.....	45,000	110,250	34,561
23–P	2.90	29,500	40,500	.....	38,000	107,500	37,069
24–P	6.87	42,500	48,300	.....	42,000	130,800	19,039
25–P	1.85	14,700	13,000	.....	41,500	74,200	40,108
26–P	3.28	28,125	37,000	.....	83,500	148,625	45,312
27–P	2.20	.....	50,750	.....	48,000	98,750	44,886
c30–P	2.62	.....	.....	57,500	.....	57,500	21,947
c31–P	3.61	.....	.....	77,100	.....	77,100	21,357
c32–P	1.09	.....	.....	47,600	.....	47,600	43,670
c33–P	1.35	.....	.....	34,000	.....	34,000	25,184
Total	30.48	152,325	261,300	216,200	319,000	949,825	31,111

In 1935, parasites were released at rates of from 10,000 to 45,000 per acre. In the Jeanerette area an average of approximately 14,000 *Trichogramma* were released per acre, but in the Houma area the average number per acre was about 31,000. The dates and approximate rates of releases made in 1935 are also shown in table 7.

Herbert Spencer, of the Division of Fruit Insect Investigations of the Bureau of Entomology and Plant Quarantine, kindly supplied from Albany, Ga., all the *Trichogramma* used in these experiments excepting those supplied by the Louisiana Agricultural Experiment Station for release in cooperative experiments. These parasites were all of the dark, Louisiana strain, being progeny of adults obtained from eggs of *Diatraea saccharalis* collected in Louisiana.

Parasites were requested as needed, and disks of cardboard containing approximately 50,000 *Sitotroga* eggs that had been exposed to parasites were sent, usually just after the eggs had turned black. A count was made on each card at 2 or more points to obtain the percentage of parasitization. The cards were cut in halves, quarters, or thirds as desired and were placed in petri dishes for emergence. The day after the parasites began to emerge a sufficiently large number usually had emerged and mated to justify their release. The dishes of parasites were protected from the sun and heat while being transported to fields for release. It was sometimes necessaryto use ice in keeping them cool. In the latter case the *Trichogramma* adults became active a few minutes after the container was placed in the open air.

Care was taken to get as even a distribution of the parasites in the field as possible. The method used was to open a dish slightly and allow the parasites to escape while the operator was walking between rows of cane. From one to three complete rounds were made in each colonized plot in releasing the parasites. The cards containing the parasitized eggs were often retained for another day or two in the dishes after the initial release to allow any parasites that had not emerged to emerge and mate before being released. If, however, practically all the parasites had emerged, the cards were torn into small pieces and placed on various cane stalks.

Rate of Parasitization

Examinations for borer egg clusters were begun in April each year. Additional examinations were made at intervals of 2 or 3 weeks thereafter until the middle or end of September. A record was kept of all egg clusters collected. In 1933 the percentage of parasitization was based only on eggs from which neither borers had hatched nor parasites had emerged. In 1934 and 1935 the percentage of parasitization was obtained on eggs from which borers had hatched or parasites had emerged as well as on eggs from which neither borers had hatched nor parasites had emerged. The parasitization was usually higher in the unhatched clusters. However, the rate of parasitization between colonized, buffer, and check plots ran in approximately the same proportion for both groups. This can be seen in tables 9 and 10.

TABLE 8.—*Data on the parasitization of eggs of the sugarcane borer by Trichogramma minutum, Louisiana, 1933.*

EXPERIMENTS IN SUGARCANE

Date examined	Colonized areas		Buffer areas [1]		Check areas	
	Total eggs	Parasitization	Total eggs	Parasitization	Total eggs	Parasitization
	Number	*Percent*	*Number*	*Percent*	*Number*	*Percent*
Apr. 7–24	225	0.0	31	0.0	155	0.0
May 1–15	0	.0			57	.0
May 19–June 1	51	.0			44	.0
June 5–16	1,033	3.3	145	.6	66	.0
June 26–July 5	428	1.4			202	3.1
July 10–13	138	.0			164	13.4
July 18–29	766	1.8			541	5.2
July 31–Aug. 17	1,784	17.1	189	10.1	1,727	21.9
Aug. 18–Sept. 8	11,274	69.5	699	96.1	7,032	67.7
Sept. 12–25	19,149	86.4	2,355	92.3	13,598	87.6
Sept. 26–28	6,211	90.3	1,545	92.5	5,037	86.7
EXPERIMENTS IN CORN						
June 5–16	58	6.9			56	7.1
June 26–July 5	57	.0			0	.0
July 18–29	276	40.8			493	17.8
July 31–Aug. 17	297	86.9			273	100.0

[1] Not all of the buffer areas were examined when colonized and check areas were examined.

Usually 1 man-hour of search was made for borer egg clusters in each of the colonized, buffer, and check plots, with the exception that early in the season when eggs were scarce and while a large number of plots were under consideration sometimes only 30 minutes was spent in each plot. At the time of collection the egg clusters were divided into four groups as follows: (1) Parasitized clusters from which no insects had emerged, (2) parasitized clusters from which emergence had begun, (3) unparasitized clusters in which no eggs had hatched, and (4) unparasitized clusters in which some or all of the eggs had hatched. The eggshells of the completely hatched or emerged clusters were counted at the time of collection or later. The parasitized eggs of the unemerged clusters were counted immediately or placed in an ice box until counted. The unhatched and apparently nonparasitized eggs were held for at least 4 days, then examined or

placed in the ice box to be counted later. This allowed any eggs that might be parasitized to turn black and thus become evident before counting. Separating the clusters from which no emergence of either parasite or borer larva had taken place at the time of collection prevented classifying them wrongly later, as a number of these clusters would begin to produce parasites or borers before the final count could be made and the empty shells might be misclassified.

TABLE 9.—*Data on 10 experiments in releases of Trichogramma minutum against the eggs of the sugarcane borer at Jeanerette and 10 at Houma, La., 1934*

Dates of examinations and plot treatments	Unhatched and unemerged eggs			Hatched, unhatched, emerged, and unemerged eggs		
	Parasitized eggs	Unparasitized eggs	Parasitization	Parasitized eggs	Unparasitized eggs	Parasitization
AT JEANERETTE, LA.						
June 18–28:	*Number*	*Number*	*Percent*	*Number*	*Number*	*Percent*
Colonized	0	474	0.0	0	738	0.0
Buffer	0	310	.0	0	451	.0
Check	0	502	.0	0	748	.0
July 21–Aug. 6:						
Colonized	398	1,961	16.9	450	4,497	9.1
Buffer	310	1,442	17.7	418	3,588	10.4
Check	626	1,122	35.8	798	3,178	20.1
Aug. 15–17:						
Colonized	7,073	1,253	85.0	9,740	4,250	69.6
Buffer	7,039	1,136	86.2	10,353	4,130	71.5
Check	7,292	1,094	87.0	10,163	4,350	70.0
Sept. 12–14:						
Colonized	7,560	1,289	85.4	16,268	2,987	84.5
Buffer	7,003	1,334	84.0	15,159	2,807	84.4
Check	6,873	1,409	83.0	15,310	2,556	86.1
AT HOUMA, LA.						
June 18–25:						
Colonized	6	459	1.3	6	1,128	0.5
Buffer	0	153	.0	0	426	.0
Check	18	460	3.8	18	718	2.4
July 20–26:						
Colonized	195	399	32.8	287	2,149	11.8
Buffer	81	275	22.8	96	1,868	4.9
Check	119	326	26.7	150	2,187	6.4
Aug. 10–16:						
Colonized	2,689	741	78.4	3,905	2,934	57.7
Buffer	3,215	867	78.8	4,325	3,381	56.1
Check	1,763	691	71.8	3,157	2,729	53.6
Sept. 11–17:						
Colonized	7,442	387	95.1	16,875	2,271	88.0
Buffer	8,523	185	97.9	16,906	1,999	89.4
Check	8,691	179	98.0	18,178	2,203	89.2

The progress of parasitization in the borer egg clusters found throughout the three seasons is shown in table 8 for 1933, in table 9 for 1934, and in table 10 for 1935. It may be seen that in 1933 the rates of parasitization in the colonized and check plots of sugarcane were closely similar from the middle of July until the end of September. In 1934, at Jeanerette, during the last of July the parasitization in the checks averaged 20.1 percent while that in the plots to be used, or which had already been used, for colonization averaged 9.1 percent. At Houma the colonized plots showed 11.8 percent parasitization to the 6.4 percent in the checks for collections made from July 20 to 26. In the September counts there was less than a 2-percent difference between the colonized, buffer, and check plots, at both Jeanerette and Houma. At this time little difference in the percentage of parasitization was expected, as the uncolonized plots

had had a chance to catch up with the colonized plots. In the collections made during the middle of August, however, a much higher percentage of parasitization should have been evident in the colonized plots than in the check plots if any benefit were derived from the releases. In the Houma experiments the colonized plots average 57.7 percent parasitization compared with 53.6 percent in the checks, or only 4 percent more, and they already had a lead of 5 percent over the checks in July. In the Jeanerette experiments in August the check, the colonized, and the buffer plots had practically the same percentage of parasitization. Although they were even in August, the colonized plots had actually gained more in parasitization since the end of July, as the checks at that time had exceeded the colonized plots in the rate of parasitization by 11 percent.

TABLE 10.—*Data on 9 experiments in releases of Trichogramma minutum against the eggs of the sugarcane borer at Jeanerette, La., and 11 at Houma, La., 1935*

AT JEANERETTE, LA.

Dates of examinations and plot treatments	Unhatched and unemerged eggs			Hatched, unhatched, emerged, and unemerged eggs		
	Parasitized eggs	Unparasitized eggs	Parasitization	Parasitized eggs	Unparasitized eggs	Parasitization
June 5–11:	*Number*	*Number*	*Percent*	*Number*	*Number*	*Percent*
Colonized	0	137	0.0	0	181	0.0
Buffer	12	150	7.4	12	245	4.7
Check	0	96	.0	0	172	.0
June 15–27:						
Colonized	66	524	11.2	69	1,238	5.3
Buffer	103	266	27.9	118	616	16.1
Check	59	398	12.9	59	678	8.0
July 2–29:						
Colonized	96	224	30.0	193	1,223	13.6
Buffer	65	23	73.9	156	563	21.7
Check	54	73	42.5	153	634	19.4
July 26–Aug. 12:						
Colonized	346	665	34.2	399	1,454	21.5
Buffer	305	665	31.4	428	1,382	23.6
Check	287	359	44.4	368	887	29.3
Aug. 26–28:						
Colonized	1,714	103	94.3	3,604	1,459	71.2
Buffer	1,235	249	83.2	3,259	1,433	69.5
Check	1,612	238	87.1	3,581	1,653	68.4
Sept. 17–23:						
Colonized	2,346	806	74.4	5,273	1,366	79.4
Buffer	2,892	824	77.3	5,294	1,417	78.9
Check	3,000	836	78.2	5,087	1,253	80.2

AT HOUMA, LA.

June 4–14:						
Colonized	11	487	2.2	11	1,144	0.1
Buffer	24	81	22.9	31	167	15.7
Check	19	251	7.0	19	369	4.9
June 17–21:						
Colonized	17	176	8.8	17	656	2.5
Buffer	0	0	.0	0	74	.0
Check	0	19	.0	0	178	.0
July 15–31:						
Colonized	23	413	5.3	40	650	5.7
Buffer	23	221	9.4	36	622	5.5
Check	22	159	12.2	48	705	6.4
Aug. 16–23:						
Colonized	410	355	53.6	711	1,771	28.7
Buffer	348	260	57.2	651	1,630	28.5
Check	861	266	76.4	1,114	2,294	32.7
Sept. 5–25:						
Colonized	2,974	209	93.4	6,213	2,331	72.7
Buffer	2,506	226	91.7	5,704	2,208	71.6
Check	2,687	224	92.3	5,686	1,910	74.9

In comparing the parasitization in borer egg clusters collected during 1935, in both the Jeanerette and Houma areas, it may be seen that the rates of parasitization between the colonized, buffer, and check plots were closely similar throughout the season, especially after the first of July. Similarly, in comparing the progress of parasitization of the borer egg clusters found throughout the three seasons, very little difference was noticed between the colonized, buffer, and check plots (figs. 2 and 3).

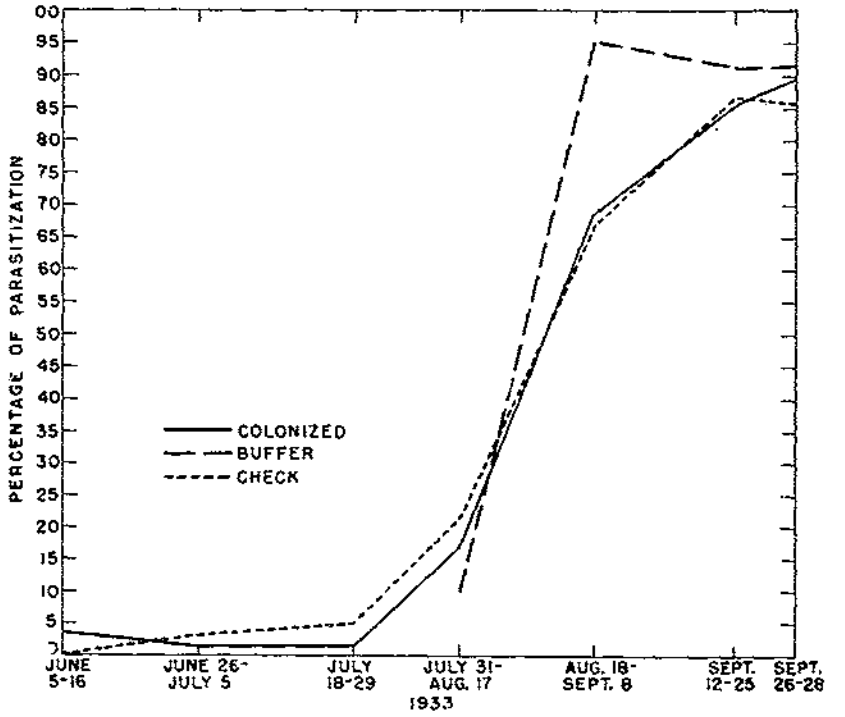


FIGURE 2.—Average percentages of parasitization in the colonized, buffer, and check plots in sugarcane in experiments on the control of the sugarcane borer by *Trichogramma minutum*, Louisiana, 1933.

During 1933, 77,972 eggs were examined to obtain the percentage of parasitization. These did not include the parasitized eggs from which the parasites had emerged or the hatched nonparasitized eggs. In 1934, 221,119 eggs were examined, including both emerged and unemerged parasitized eggs and the hatched and unhatched nonparasitized eggs. In 1935, 94,766 eggs were examined for parasitism, including emerged and unemerged borer eggs. Fewer eggs were examined in 1935 than in 1934, more because examinations were made at greater intervals than because of any reduction in the borer infestation. Data on the collection and examination of borer eggs are given in detail in table 11 for experiments c2 in 1934 and c20 in 1935. This table shows the progress of parasitization in representative plots in the cooperative experiments.

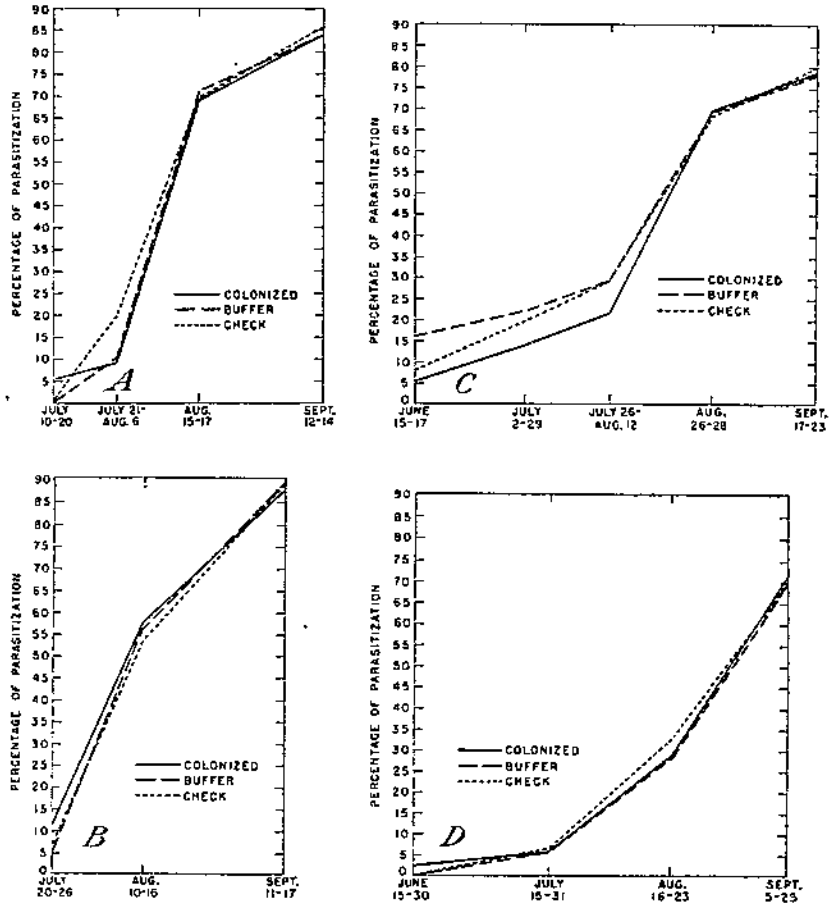


FIGURE 3.—Average percentage of parasitization in the colonized, buffer, and check plots in sugarcane in experiments on the control of the sugarcane borer by *Trichogramma minutum* in experiments at: *A*, Jeanerette, La., in 1934; *B*, Houma, La., in 1934; *C*, Jeanerette in 1935; *D*, Houma in 1935.

TABLE 11.—*Progress of parasitization in representative plots of the cooperative experiments in mass releases of Trichogramma minutum for the control of the sugarcane borer in Louisiana, 1934 and 1935*

HOUMA EXPERIMENT c2, 1934

Date of examination	Time spent in examination	Condition of eggs in—											
		Colonized plot				Buffer plot				Check plot			
		Unhatched and unemerged		Hatched, unhatched, emerged, and unemerged		Unhatched and unemerged		Hatched, unhatched, emerged, and unemerged		Unhatched and unemerged		Hatched, unhatched, emerged, and unemerged	
	Minutes	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*
Apr. 17	30	27	0.0	27	0.0	0	0.0	0	0.0	0	0.0	0	0.0
May 17	30	0	.0	0	.0	0	.0	0	.0	0	.0	0	.0
June 4	30	20	.0	20	.0	34	.0	34	.0	69	.0	69	.0
June 12	30	29	.0	29	.0	10	.0	31	.0	32	.0	32	.0
June 18	30	45	.0	74	.0	59	.0	86	.0	147	.0	189	.0
July 9	30	16	100.0	192	8.3	0	.0	220	.0	83	.0	235	.0
July 20	30	19	100.0	193	9.8	0	.0	0	.0	0	.0	0	.0
July 26	30	148	6.0	397	2.3	19	.0	141	.0	39	.0	230	.0
Aug. 14	60	654	85.3	1,000	76.9	474	67.8	891	45.4	303	67.6	758	55.8
Sept. 12	60	1,101	95.9	1,976	92.1	996	100.0	2,335	87.4	803	96.1	1,672	86.1
Oct. 5	20	359	94.2	687	89.8	211	86.3	602	86.0	141	82.3	408	93.4

JEANERETTE EXPERIMENT c20, 1935

June 17	60	129	20.2	211	11.3	189	29.1	255	27.1	132	26.5	193	18.1
July 6	60	28	100.0	125	31.2	22	68.2	225	32.0	14	100.0	180	39.4
July 27	60	66	9.1	294	2.3	176	51.2	301	29.6	32	28.1	140	20.3
Aug. 28	60	420	96.2	853	74.1	294	75.9	997	69.1	304	100.0	1,047	68.8
Sept. 18	60	235	91.9	646	92.3	349	92.6	860	87.1	253	83.0	505	90.7

BORER-INFESTATION COUNTS

In the fall of each year borer-infestation counts were made, and the percentage of joints bored was calculated. An average of 150 stalks were examined from each of the 3 plots in 1933, but in 1934 and 1935, 200 stalks were examined from each of the 3 plots. The total number of joints and the joints bored externally were recorded for each stalk. Holes made by the borer larvae for the exit of the moth were recorded in 1934 and 1935, but the data on exit holes were considered questionable, as it was not always possible to distinguish between exit holes and other holes made by large larvae.

The data from these experiments are given in detail in table 12, with each set of experiments summarized at the end of each section of the table.

TABLE 12.—*Experiments in the mass liberation of Trichogramma minutum. Infestation by the sugarcane borer in colonized, buffer, and check plots of sugarcane as judged by the number of stalks and joints bored*

HOUMA AND JEANERETTE, LA., 1933

Variety and crop	Plot No.	Treatment	Stalks		Joints		Exit holes
			Total examined	Bored	Total examined	Bored	
			Number	*Percent*	*Number*	*Percent*	*Number*
P. O. J. 234, first stubble	1	Colonized	105	91.4	1,565	33.4	
	2	Buffer	105	92.3	1,485	27.7	
	3	Check	105	93.3	1,463	28.0	
	4	Colonized	150	86.0	2,047	20.9	
	5	Buffer	75	69.3	915	17.9	
	6	Check	150	83.3	2,209	18.6	
	7	Buffer	75	98.7	1,088	30.8	
	8	Colonized	150	98.0	2,185	32.0	
	20	Colonized	150	79.3	2,211	15.7	
	21	Buffer	45	62.2	681	7.3	
	22	Check	150	73.3	2,113	13.7	
	113	Colonized	150	99.3	2,121	34.8	
	114	Buffer	150	94.0	2,037	31.1	
	115	Check	150	94.6	2,023	29.0	
P. O. J. 234, plant	109	Colonized	150	100.0	2,166	49.7	
	111	Check	150	99.3	2,112	48.2	
P. O. J. 213, plant	9	Colonized	150	100.0	2,020	44.2	
	10	Buffer	150	99.3	2,054	38.7	
	11	Check	150	100.0	2,007	40.3	
	12	Colonized	300	88.3	3,932	29.1	
	16	Check	300	77.7	3,741	18.2	
P. O. J. 213, first stubble	19	Colonized	200	93.5	2,335	41.0	
	18	Buffer	175	100.0	1,887	39.9	
	17	Check	200	99.0	2,419	39.6	
	106	Colonized	150	100.0	1,544	54.5	
	107	Check	150	97.3	1,487	47.9	
	108	Colonized	150	99.3	1,589	51.6	
	127	Colonized	150	96.0	1,611	33.3	
	126	Check	150	99.3	1,592	38.3	
P. O. J. 213, second stubble	124	Colonized	50	100.0	552	58.0	
	125	Check	50	98.0	585	43.6	
P. O. J. 213, second stubble	13	Colonized	350	99.7	4,067	45.6	
	14	Buffer	25	100.0	273	39.6	
	15	Check	350	94.6	4,009	31.5	
Total and average	14	Colonized	2,355	95.4	29,945	37.3	
	8	Buffer	800	92.6	10,420	31.2	
	12	Check	2,055	91.4	26,150	31.1	

JEANERETTE, LA., 1934

P. O. J. 213, first stubble	1	Colonized	200	89.5	2,132	26.08	28
	1	Buffer	210	97.1	2,234	32.23	39
	1	Check	200	97.0	2,141	31.62	31
P. O. J. 213, second stubble	2	Colonized	200	93.5	2,362	28.54	31
	2	Buffer	210	87.1	2,261	27.16	27
	2	Check	200	72.0	2,087	15.29	10
P. O. J. 234, plant	3	Colonized	200	87.0	3,005	21.26	49
	3	Buffer	200	92.5	3,123	20.88	53
	3	Check	200	95.5	3,033	21.50	44
Co. 281, first stubble	4	Colonized	200	91.5	2,244	26.38	29
	4	Buffer	200	80.5	2,096	24.90	27
	4	Check	200	79.0	2,117	18.14	19
P. O. J. 234, plant	5	Colonized	150	79.3	2,049	18.06	31
	5	Buffer	150	90.7	2,158	26.88	74
	5	Check	150	96.0	2,249	29.06	76

TABLE 12.—*Experiments in the mass liberation of Trichogramma minutum. Infestation by the sugarcane borer in colonized, buffer, and check plots of sugarcane as judged by the number of stalks and joints bored*—Continued

JEANERETTE, LA., 1933—Continued

Variety and crop	Plot No.	Treatment	Stalks		Joints		Exit holes
			Total examined	Bored	Total examined	Bored	
			Number	*Percent*	*Number*	*Percent*	*Number*
Co. 290, plant	6	Colonized	50	96.0	503	29.22	15
	6	Buffer	50	72.0	477	16.14	1
	6	Check	50	98.0	464	28.88	12
Co. 281, plant	7	Colonized	200	96.0	2,342	34.97	66
	7	Buffer	200	97.0	2,398	37.66	91
	7	Check	200	99.0	2,415	40.54	80
	7a	Colonized	50	98.0	442	43.67	18
	7a	Buffer	50	96.0	502	38.84	15
	7a	Check	50	98.0	468	39.74	20
P. O. J. 234, first stubble	8	Colonized	200	85.5	2,702	23.75	65
	8	Buffer	200	93.0	2,695	28.31	88
	8	Check	200	87.5	2,708	20.00	76
P. O. J. 234, plant	9	Colonized	200	85.5	2,945	17.32	25
	9	Buffer	200	83.0	2,958	16.09	20
	9	Check	200	83.5	2,983	16.09	29
P. O. J. 234, plant	10	Colonized	200	100.0	2,707	50.85	219
	10	Buffer	200	99.0	2,838	49.30	201
	10	Check	200	99.0	2,741	47.32	198
Total and average		Colonized	1,850	90.43	23,523	28.49	576
		Buffer	1,870	91.70	23,740	27.93	636
		Check	1,850	90.11	23,406	27.33	595

HOUMA, LA., 1934

Co. 281, plant	c1	Colonized	210	89.5	2,724	30.21	53
	c1	Buffer	210	87.6	2,685	27.00	37
	c1	Check	210	83.8	2,836	20.41	25
P. O. J. 234, first stubble	c2	Colonized	200	100.0	2,800	39.16	70
	c2	Buffer	210	100.0	3,175	33.32	52
	c2	Check	200	99.5	3,167	30.47	32
P. O. J. 213, first stubble	3	Colonized	200	99.0	2,428	36.82	57
	3	Buffer	210	99.0	2,747	29.23	31
	3	Check	200	99.5	2,610	27.51	36
P. O. J. 213, second stubble	4	Colonized	200	99.5	2,031	43.86	78
	4	Buffer	210	98.1	2,152	30.06	45
	4	Check	200	98.5	2,114	31.50	30
P. O. J. 234, first stubble	5	Colonized	200	78.5	2,676	18.75	38
	5	Buffer	210	84.8	2,752	19.00	25
	5	Check	200	74.5	2,573	13.64	15
P. O. J. 213, first stubble	6	Colonized	200	93.0	2,414	25.76	54
	6	Buffer	200	97.0	2,629	27.04	71
	6	Check	200	74.5	2,590	14.24	22
	7	Colonized	200	98.0	2,368	31.33	48
	7	Buffer	200	98.0	2,307	30.50	37
	7	Check	200	94.0	2,300	20.00	39
	8	Colonized	200	98.0	2,540	30.07	44
	8	Buffer	200	90.0	2,483	20.56	38
	8	Check	200	97.5	2,519	25.69	18
	9	Colonized	200	99.0	2,480	32.22	28
	9	Buffer	200	95.5	2,439	27.14	34
	9	Check	200	97.0	2,535	25.80	24

TABLE 12.—*Experiments in the mass liberation of Trichogramma minutum. Infestation by the sugarcane borer in colonized, buffer, and check plots of sugarcane as judged by the number of stalks and joints bored*—Continued

HOUMA, LA., 1934—Continued

Variety and crop	Plot No.	Treatment	Stalks		Joints		Exit holes
			Total examined	Bored	Total examined	Bored	
			Number	*Percent*	*Number*	*Percent*	*Number*
P. O. J. 234, first stubble	10	Colonized	200	94.0	2,584	24.03	33
	10	Buffer	200	97.0	2,740	22.11	33
	10	Check	200	92.0	2,832	20.48	39
Total and average		Colonized	2,010	94.82	25,197	31.07	501
		Buffer	2,050	95.55	26,169	27.43	405
		Check	2,010	91.04	26,100	23.76	286

JEANERETTE, LA., 1935

Co. 290, plant	3	Colonized	200	80.50	2,833	14.65	52
	3	Buffer	200	51.00	2,845	7.14	19
	3	Check	200	35.50	2,807	4.24	12
	4	Colonized	200	42.00	2,829	4.95	16
	4	Buffer	200	41.50	2,746	5.54	14
	4	Check	200	55.00	2,745	7.47	20
Co. 281, first stubble	7	Colonized	200	94.00	2,341	25.42	35
	7	Buffer	200	86.00	2,272	25.48	39
	7	Check	200	75.50	2,240	17.41	24
P. O. J. 213, plant	8	Colonized	200	60.00	2,601	8.84	11
	8	Buffer	200	60.50	2,642	9.27	14
	8	Check	200	76.00	2,464	14.94	30
	10	Colonized	200	85.50	2,723	17.74	45
	10	Buffer	200	87.50	2,688	18.27	35
	10	Check	200	87.00	2,737	19.80	45
Co. 290, first stubble	c13	Colonized	200	76.00	2,585	16.13	56
	c13	Buffer	200	87.50	2,454	22.05	99
	c13	Check	200	74.00	2,478	15.42	72
Co. 281, first stubble	14	Colonized	200	70.00	2,189	15.90	25
	14	Buffer	200	69.50	2,154	16.02	13
	14	Check	200	79.00	2,122	17.06	21
Co. 281, second stubble	c19	Colonized	200	80.00	2,104	20.91	34
	c19	Buffer	200	82.50	2,203	20.65	52
	c19	Check	200	85.00	2,157	24.57	58
Co. 281, first stubble	c20	Colonized	200	87.50	2,268	23.10	48
	c20	Buffer	200	87.00	2,319	26.78	62
	c20	Check	200	94.50	2,350	26.51	58
Total and average		Colonized	1,800	75.06	22,473	15.98	322
		Buffer	1,800	72.56	22,323	16.27	347
		Check	1,800	73.50	22,100	15.93	340

HOUMA, LA., 1935

P. O. J. 234, first stubble	21	Colonized	200	95.5	2,674	22.73	16
	21	Buffer	200	89.0	2,756	19.23	14
	21	Check	200	77.5	2,809	13.99	13
	22	Colonized	200	85.5	2,726	19.88	15
	22	Buffer	200	85.5	2,773	15.50	4
	22	Check	200	87.5	2,822	17.43	8
C. P. 807, first stubble	23	Colonized	200	70.0	2,853	9.09	5
	23	Buffer	200	61.0	2,830	7.56	6
	23	Check	200	51.5	2,974	5.58	6

TABLE 12.—*Experiments in the mass liberation of Trichogramma minutum. Infestation by the sugarcane borer in colonized, buffer, and check plots of sugarcane as judged by the number of stalks and joints bored*—Continued

HOUMA, LA., 1935—Continued

Variety and crop	Plot No.	Treatment	Stalks		Joints		Exit holes
			Total examined	Bored	Total examined	Bored	
			Number	*Percent*	*Number*	*Percent*	*Number*
	24	Colonized	200	73.5	2,554	12.37	8
	24	Buffer	200	81.0	2,577	14.28	11
	24	Check	200	88.5	2,649	19.02	11
	25	Colonized	200	87.0	2,118	23.04	16
Co. 281, first stubble	25	Buffer	200	84.5	2,106	18.04	22
	25	Check	200	80.0	2,150	15.76	13
	26	Colonized	200	88.5	2,049	24.64	20
	26	Buffer	200	80.0	2,178	19.69	16
	26	Check	200	85.5	2,200	20.68	15
	27	Colonized	200	82.0	2,751	18.28	19
Co. 281, plant	27	Buffer	200	80.0	2,567	10.46	14
	27	Check	200	89.0	2,764	21.92	26
	c30	Colonized	200	65.5	2,784	9.16	9
C. P. 807, first stubble	c30	Buffer	200	72.0	2,824	11.68	12
	c30	Check	200	60.0	2,740	8.36	10
	c31	Colonized	200	92.5	2,332	27.96	9
	c31	Buffer	200	93.5	2,428	29.90	13
	c31	Check	200	92.0	2,487	27.86	7
	c32	Colonized	200	91.5	2,316	27.72	6
Co. 281, first stubble	c32	Buffer	200	82.0	2,319	20.57	13
	c32	Check	200	84.0	2,269	21.68	23
	c33	Colonized	200	76.0	2,240	18.70	18
	c33	Buffer	200	68.0	2,474	13.70	12
	c33	Check	200	68.0	2,412	13.35	17
		Colonized	2,200	82.32	27,397	19.03	141
Total and average		Buffer	2,200	70.64	27,932	16.76	137
		Check	2,200	78.50	28,276	16.59	149

It may be noted that in most of the experiments the borer infestation was high, thus allowing an opportunity for a wider difference in infestation between colonized plots and check plots. The results of these experiments show that the borer infestation in the colonized plots increased to as great an extent as in the check plots, notwithstanding the large number of *Trichogramma* released.

The number of joints and stalks for examination was not selected because it was thought the best unit for a sample, as the reliability of sampling data increases with the size of the sample, but because it was as large a sample as could be obtained per plot at that time of year with the help available.

An individual record was kept of each stalk examined. To secure the standard deviation in the percentage of infestation and the coefficient of variation, the stalks examined in the Jeanerette area in 1934 were grouped in sets of 10 each. The variants in percentage of infestation were grouped in classes ranging in percentage of joint infestation from 1 to 5, 6 to 10, etc., and calculations were based on the centers of the class intervals. The results of these calculations are given in table 13.

It will be noted that the coefficient of variation is rather high. It is not so great, however, but that the mean percentage of infestation of a sample of 200 stalks can be used to give a fairly representative picture

of borer injury in a given plot. This is especially true where there is a difference in the mean of 5 percent or more between 2 plots of the same experiment.

TABLE 13.—*Percentage of joint infestation of 20 bundles of 10 stalks each of sugarcane in experiments on the mass liberations of Trichogramma minutum to control the sugarcane borer, Jeanerette, La., 1934*

Variety and crop	Plot No.	Treatment	Mean	Standard deviation	Coefficient of variation
			Percent	*Percent*	*Percent*
P. O. J. 213, first stubble	1	Colonized	25.75	7.4958	29.11
	1	Buffer	31.81	10.9005	34.27
	1	Check	31.50	9.5000	30.16
P. O. J. 213, second stubble	2	Colonized	28.75	8.4075	29.24
	2	Buffer	27.28	9.9043	36.31
	2	Check	15.00	7.6485	50.99
P. O. J. 234, plant	3	Colonized	21.50	12.4599	57.95
	3	Buffer	21.25	8.4075	39.56
	3	Check	22.00	6.8199	30.99
Co. 281, first stubble	4	Colonized	20.00	8.5732	32.97
	4	Buffer	25.25	5.5845	22.12
	4	Check	17.50	6.1032	34.88
Co. 281, plant	7	Colonized	35.50	11.8848	33.48
	7	Buffer	38.25	11.1214	29.08
	7	Check	42.25	13.1600	31.15
P. O. J. 234, first stubble	8	Colonized	23.75	10.1581	42.77
	8	Buffer	28.75	8.5549	29.76
	8	Check	26.50	11.6297	43.89
P. O. J. 234, plant	9	Colonized	18.00	6.8920	38.29
	9	Buffer	16.25	5.5396	34.09
	9	Check	15.75	8.5841	54.50
	10	Colonized	57.50	9.0691	15.77
	10	Buffer	48.75	12.7744	26.20
	10	Check	47.25	10.4013	22.01

In addition to the external count of the bored joints a number of stalks were split each year, and an internal examination and count was made of the actual number of joints bored and borer larvae, pupae, and pupal skins found. A summary of the data obtained through splitting the canes in the various experiments in the years 1933, 1934, and 1935 are shown in table 14.

TABLE 14.—*Summary of infestation by the sugarcane borer in the canes split in the Trichogramma plots, Louisiana, 1933–35*

Year and locality	Plot treatment	Stalks split	Total joints	Joints bored externally	Joints bored internally	Larvae	Pupae	Pupal skins	Exit holes
		Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
1933, Jeanerette, and Houma, combined.	Colonized	700	8,033	3,149	3,359	289	10	167	225
	Buffer	285	3,033	1,028	1,136	86	6	37	42
	Check	600	7,068	2,398	2,556	181	2	109	133
1934, Jeanerette	Colonized	500	5,823	1,773	1,844	43	7	101	141
	Buffer	500	5,778	1,789	1,848	41	1	125	168
	Check	500	5,085	1,625	1,677	44	1	131	101
1934, Houma	Colonized	500	6,146	1,837	2,055	78	3	99	105
	Buffer	500	6,540	1,541	1,692	67	7	57	68
	Check	500	6,411	1,492	1,630	53	4	58	59
1935, Houma	Colonized	550	7,140	1,206	1,464	76	1	31	36
	Buffer	550	7,152	1,223	1,379	68	2	39	39
	Check	550	7,254	1,187	1,336	54	2	40	45

Effect of Colonizations on Percentage of Millable Cane

It is a well-known fact that a large percentage of the cane plants produced each season never reach millable size. There are probably several factors involved in the loss of such a large number of plants. Many of them die or become stunted through lack of light and possibly plant food.

Hinds, Osterberger, and Dugas (7) investigated the effect of the borer in causing unmillable cane and reported that

> The effect of *Trichogramma* colonization upon the proportion of original stalks developing to millable size and condition appears to be significant, and yields some very interesting comparisons which indicate the value of early season colonization.

A further study was made by the writers of the value of *Trichogramma* colonizations in increasing the percentage of millable cane in the colonized, buffer, and check plots in two experiments carried on cooperatively with the Louisiana Agricultural Experiment Station in 1934, and in four cooperative experiments in 1935. Plants classed as unmillable included all that were dead or so small that they would have been left in the field with the trash at harvest time. These unmillable plants were split to determine the percentage injured by the borer. Examinations of like character were made in both years in cane growing near Rosewood and Bunkie, La., where borer injury is the lightest in the sugar district, as it is interesting to compare findings there with those from the cooperative experiments in which borer injury was much above the average for the sugar district. Data covering these examinations are given in table 15.

TABLE 15.—*Effects of Trichogramma colonization and sugarcane borer injury on the percentage of millable sugarcane plants, Louisiana, 1934–35*

Trichogramma experiment No., variety and crop	Plot treatment	Date examined	Samples examined [1]	Millable plants		Plants not millable	
						Total	Bored
		1934	*Number*	*Number*	*Percent*	*Number*	*Percent*
c1, Co. 281, plant cane	Colonized	Dec. 10	6	312	47.7	341	14.1
	Buffer	do	6	305	48.7	321	16.8
	Check	do	6	317	52.2	296	14.8
c2, P. O. J. 234, plant cane	Colonized	Nov. 20	6	244	53.7	210	22.8
	Buffer	do	6	283	55.1	230	11.7
	Check	do	6	246	58.9	171	15.2
(Rosewood-Bunkie area):							
P. O. J. 234		Oct. 2	33	1,308	59.0	907	.8
Co. 281		do	20	1,034	56.6	791	.5
		1935					
c30, C. P. 807, stubble cane	Colonized	Oct. 17	6	315	66.5	159	2.5
	Buffer	do	6	309	66.2	153	4.8
	Check	do	6	321	63.2	187	10.2
c31, Co. 281, stubble cane	Colonized	Nov. 20	6	296	53.0	253	10.7
	Buffer	do	6	270	49.8	272	14.0
	Check	do	6	273	54.8	225	14.7
c32, Co. 281, stubble cane	Colonized	do	6	283	48.5	300	13.3
	Buffer	do	6	281	51.5	265	7.9
	Check	do	6	285	51.7	260	9.8
c33, Co. 281, stubble cane	Colonized	do	6	255	52.2	234	13.7
	Buffer	do	6	261	47.0	294	11.2
	Check	do	6	253	51.7	236	8.5
(Rosewood-Bunkie area):							
Co. 281, plant		Oct. 10	28	1,034	53.4	904	.11
Co. 281, stubble		Oct. 9	30	1,457	59.2	1,005	.20
Co. 290, plant		Oct. 10	25	1,220	56.4	943	.00
Co. 290, stubble		Oct. 11	25	1,207	57.7	882	.00

[1] Each sample consisted of 10 feet of row.

It may be noted that the percentage of millable plants was as great in the uncolonized as in the colonized plots. Borer injury to unmillable cane was also practically the same in colonized and check plots.

Comparing the percentage of millable plants in the heavily bored plots of the *Trichogramma* experiments with the percentage in the Rosewood-Bunkie area little correlation is apparent between borer injury and the percentage of millable plants.

The results of examinations made at Rosewood during the harvest season of 1934 are of special interest, since a total of 850 millable stalks were examined without finding any indication of borer injury. In spite of the absence of borers the percentage of plants too small to be millable was almost as high as in the Houma area.

Yield in Sugar and Cane per Acre

The final conclusion on whether the release of *Trichogramma minutum* is of value in the control of the sugarcane borer must be based on the quantity of sugar produced per acre of cane in the colonized areas in excess of that produced in the areas where no parasites were released. This increase of sugar might result from greater tonnage of sugarcane or from more sugar per ton of cane, due to less borer injury, or from both.

In 1933 an observer checked all the cars loaded from experimental plots to obtain the correct net weight of cane from each plot. Five or six plantation carloads from each plot were tagged with a special card indicating that they were to be milled together and a composite sample taken by the factory chemist.

In 1934 and 1935 the same method of obtaining the net weight of cane and the factory mill sample was used as in 1933, except that the weight and also a factory juice sample of each cut in each plot were obtained. Where possible, four or more plantation carloads were tagged from each cut for a composite juice sample, and in the Houma experiments one or more composite samples were taken from all the cane in each cut. In some experiments the cane was hauled to the mill by motortruck or wagon, and in such cases two wagonloads per cut were used for a sample. In selecting wagonloads and carloads for sucrose analyses, where the entire cut was not used for a sample, care was taken during all three seasons to get cane from the middle of the cuts and not from the heap rows along the drain ditches.

As a precaution against failure to get analyses of factory juice, analyses were also made by use of a small mill. In 1933, 150 stalks were cut from each plot, 15 stalks from 10 representative points, that is, 4 points near each end and 2 in the middle. In 1934 and 1935, 10 stalks were taken at 5 representative points in each plot, or at 6 points in 1934 when there were 3 cuts of cane in the plot. These samples were ground in the experimental mill of the Division of Soil Fertility of the Bureau of Plant Industry at Houma. In 1933 and 1934 juice analyses were made under the supervision of N. McKaig, Jr., and in 1935 the analyses were made under the supervision of A. M. O'Neal or G. Arceneaux. The comparative analyses between the 3 plots of an experiment when obtained by small-mill samples agreed very closely with the factory-juice analyses from the same 3 plots. The figures for the small-mill analyses were often lower than those of the factory analyses for the same experiment, as the small samples were taken

sometimes several days before the cane of the experiment was harvested. It was apparant that factory analyses of wagonload and carload lots were more accurate than small-mill samples from a small number of stalks, for determining the sugar produced per acre.

Table 16 gives the data from the various experiments showing the number of acres per plot, pounds of 96° sugar per ton of cane calculated from both the small-mill analyses and the factory analyses, tons of cane harvested per acre, and the pounds of 96° sugar per acre based on the factory analyses. It may be noted that in 1933 only one colonized plot, 20–P, surpassed its check in both pounds of sugar per ton of cane (factory analysis) and pounds of sugar per acre. There was one colonized plot, 9–P, which surpassed its check in pounds of sugar per ton of cane, but it was below its check in pounds of sugar per acre, and 113–P and 124–P surpassed their checks in pounds of sugar per acre but were below the checks in pounds of sugar per ton of cane on the basis of factory analysis. In comparing the averages of the colonized, buffer, and check plots, it may be noted that the yield of the check plots surpassed that of the colonized plots by 10.3 pounds of sugar per ton of cane and by 220 pounds of sugar per acre. The buffer plots gave less sugar per ton of cane but more sugar per acre than either colonized or check plots.

TABLE 16.—*Yield of sugar and related data on the colonized, buffer, and check plots in the experiments on the mass liberations of Trichogramma minutum in Louisiana, 1933–35*

COMBINED DATA FROM HOUMA AND JEANERETTE EXPERIMENTS, 1933

Variety and crop	Plot No.	Treatment	Size of plot	96° sugar per ton of cane				Cane per acre	Sugar per acre based on factory analysis
				Small-mill analysis		Factory analysis			
				Date cut	Quantity	Date cut	Quantity		
			Acres		*Pounds*		*Pounds*	*Tons*	*Pounds*
P. O. J. 234, first stubble.	1	Colonized	2.73	Oct. 12	118.5	Oct. 21	122.1	15.84	1,934
	2	Buffer	2.88	do	142.4	do	155.1	15.86	2,460
	3	Check	2.99	do	134.0	do	145.0	17.45	2,530
	4	Colonized	7.49	Oct. 13	137.2	Oct. 19	160.9	15.42	2,481
	5	Buffer	3.90	do	145.7	do	159.0	15.05	2,393
	6	Check	7.12	do	151.0	do	164.6	15.71	2,586
	7	Buffer	2.91	do	133.0	do	143.2	17.01	2,436
	8	Colonized	8.24	do	126.3	do	134.7	15.68	2,112
	20	Colonized	19.78	Oct. 10	129.2	Oct. 26	138.5	17.71	2,453
	21	Buffer	4.24	do	129.7	do	133.2	17.70	2,358
	22	Check	15.09	do	129.9	do	128.1	15.61	2,000
	113	Colonized	15.00	Nov. 9	165.7	Oct. 31	147.2	12.94	1,905
	114	Buffer	15.00	do	165.8	do		13.34	2,212
	115	Check	15.00	do	160.4	do	166.4	11.27	1,875
P. O. J. 234, plant	109	Colonized	18.28	Nov. 16	181.1	Dec. 6	182.6	7.71	1,408
	111	Check	20.28	do	167.3	do	100.5	8.79	1,674
P. O. J. 213, plant	9	Colonized	3.50	Nov. 27	182.6	Dec. 2	158.1	19.11	3,021
	10	Buffer	3.83	do	183.7	do	147.8	22.87	3,380
	11	Check	3.92	do	161.3	do	141.9	22.26	3,159
	12	Colonized	7.89	do	166.1	Dec. 7	133.7	16.58	2,217
	16	Check	12.99	do	185.7	Dec. 6	155.4	17.23	2,678

TABLE 16.—*Yield of sugar and related data on the colonized, buffer, and check plots in the experiments on the mass liberations of Trichogramma minutum in Louisiana, 1933–35*—Continued

COMBINED DATA FROM HOUMA AND JEANERETTE EXPERIMENTS, 1933—Con.

Variety and crop	Plot No.	Treatment	Size of plot	96° sugar per ton of cane				Cane per acre	Sugar per acre based on factory analysis
				Small-mill analysis		Factory analysis			
				Date cut	Quantity	Date cut	Quantity		
			Acres		*Pounds*		*Pounds*	*Tons*	*Pounds*
	19	Colonized	8.54	Oct. 20	131.2	Oct. 29	106.0	23.52	2,493
	18	Buffer	6.01	do	131.6	do	125.4	18.60	2,332
	17	Check	8.78	do	137.9	Nov. 4	125.6	19.90	2,500
P. O. J. 213, first stubble.	106	Colonized	13.29	Nov. 6	148.8	Nov. 13	131.3	9.80	1,260
	107	Check	23.50	do	169.0	Nov. 15	177.7	9.91	1,781
	108	Colonized	26.10	do	164.5	Nov. 13	166.3	9.56	1,590
	127	Colonized	4.49	Nov. 9	161.6	Nov. 10	176.7	14.40	2,544
	126	Check	12.79	do	159.0	do	184.8	17.17	3,173
	124	Colonized	19.00	do	131.5	Nov. 9	135.1	4.45	601
P. O. J. 213, second stubble.	125	Check	19.65	do	140.4	Nov. 8	137.9	4.08	563
	13	Colonized	8.01	Oct. 20	103.5	Oct. 28	101.5	16.46	1,671
	14	Buffer	3.20	do	91.9	do	111.7	18.64	2,104
	15	Check	7.97	do	112.1	do	115.3	16.95	1,954
Averages		14 Colonized	11.59		146.3		142.5	14.21	2,025
		8 Buffer	5.24		140.5		139.3	17.41	2,425
		12 Check	12.50		150.7		152.8	14.69	2,245

HOUMA EXPERIMENTS, 1934

Co. 281, plant	c1	Colonized	5.36	Nov. 6	160.8	Dec. 29	138.2	25.83	3,570
	c1	Buffer	5.51	do	171.0	do	144.6	26.00	3,760
	c1	Check	5.10	do	188.0	Dec. 28	145.5	24.16	3,515
P. O. J. 234, plant	c2	Colonized	3.19	do	174.6	Dec. 19	149.6	16.70	2,498
	c2	Buffer	4.56	do	180.8	Dec. 18	138.9	18.81	2,613
	c2	Check	2.98	do	172.2	Dec. 16	148.7	18.09	2,690
P. O. J. 213, first stubble.	3	Colonized	3.56	Oct. 12	158.9	Nov. 15	186.9	16.83	3,146
	3	Buffer	6.55	do	162.4	do	190.2	17.23	3,277
	3	Check	4.52	do	163.7	do	192.3	18.22	3,504
P. O. J. 213, second stubble.	4	Colonized	4.96	do	125.7	Oct. 26	161.8	12.91	2,089
	4	Buffer	7.03	do	137.2	Oct. 27	168.9	12.31	2,054
	4	Check	3.05	do	147.0	do	163.3	12.29	2,007
P. O. J. 234, first stubble.	5	Colonized	3.15	do	152.5	Oct. 20	171.2	13.16	2,253
	5	Buffer	5.10	do	147.5	Oct. 21	166.9	13.22	2,206
	5	Check	3.49	do	157.8	do	181.6	12.22	2,219
	6	Colonized	4.58	do	156.0	Oct. 22	167.1	12.88	2,152
	6	Buffer	7.18	do	154.0	do	167.9	13.83	2,322
	6	Check	4.76	do	155.1	do	167.1	12.40	2,072
P. O. J. 213, first stubble.	7	Colonized	3.35	do	146.4	Oct. 18	153.3	14.09	2,160
	7	Buffer	3.77	do	147.3	Oct. 17	146.6	14.82	2,173
	7	Check	4.05	do	137.8	do	142.2	13.08	1,860
	8	Colonized	3.25	do	147.4	Oct. 21	172.0	16.11	2,771
	8	Buffer	4.75	do	158.2	do	171.4	17.66	3,027
	8	Check	3.22	do	148.6	do	174.1	15.85	2,759
P. O. J. 234, first stubble.	0	Colonized	3.37	do	157.6	Oct. 26	178.0	13.14	2,339
	9	Buffer	4.84	do	153.4	Oct. 25	169.7	15.35	2,605
	9	Check	3.01	do	146.0	do	167.7	16.40	2,750
	10	Colonized	4.26	do	167.4	Oct. 19	166.3	14.90	2,478
	10	Buffer	6.33	do	153.4	do	160.2	14.80	2,371
	10	Check	3.22	do	155.6	Oct. 20	158.9	13.70	2,177
Averages		Colonized	3.90		154.7		164.4	15.66	2,575
		Buffer	5.56		156.5		162.3	16.40	2,662
		Check	3.74		157.2		164.1	15.64	2,567

TABLE 16.—*Yield of sugar and related data on the colonized, buffer, and check plots in the experiments on the mass liberations of Trichogramma minutum in Louisiana, 1933–35*—Continued

JEANERETTE EXPERIMENTS, 1934

Variety and crop	Plot No.	Treatment	Size of plot	96° sugar per ton of cane				Cane per acre	Sugar per acre based on factory analysis
				Small-mill analysis		Factory analysis			
				Date cut	Quantity	Date cut	Quantity		
			Acres		*Pounds*		*Pounds*	*Tons*	*Pounds*
P. O. J. 213, first stubble.	1	Colonized	7.84	Oct. 18	183.0	Oct. 30	192.5	12.23	2,354
	1	Buffer	9.57	do	176.3	do	200.4	13.37	2,679
	1	Check	5.23	do	183.8	do	191.9	14.25	2,735
P. O. J. 213, second stubble.	2	Colonized	4.15	do	179.1	Nov. 2	202.5	10.35	2,096
	2	Buffer	5.10	do	182.6	Nov. 1	204.0	10.55	2,152
	2	Check	2.74	do	190.1	do	212.2	10.01	2,124
P. O. J. 234, plant	3	Colonized	3.82	Nov. 2	197.9	Nov. 23		17.88	3,538
	3	Buffer	6.40	do	202.3	Nov. 22	218.4	16.91	3,693
	3	Check	2.50	do	195.7	do	212.1	17.23	3,654
Co. 281, first stubble.	4	Colonized	3.64	Oct. 30	212.7	Oct. 31	196.2	10.54	2,068
	4	Buffer	3.43	do	202.7	do	208.5	10.16	2,118
	4	Check	3.31	do	206.0	do	200.0	11.19	2,238
Co. 281, plant	7	Colonized	3.05	Nov. 8	175.5	Dec. 13	208.9	20.53	4,289
	7	Buffer	3.14	do	174.7	Dec. 19	198.5	21.04	4,176
	7	Check	2.96	do	159.1	do	183.4	21.96	4,027
P. O. J. 234, first stubble.	8	Colonized	6.90	Oct. 11	148.4	Oct. 23	162.4	11.83	1,921
	8	Buffer	6.90	do	143.5	do	160.9	12.80	2,316
	8	Check	7.18	do	139.2	Oct. 24	172.5	11.71	2,020
P. O. J. 234, plant	9	Colonized	2.97	Nov. 5	202.1	Dec. 4	234.2	17.35	4,070
	9	Buffer	6.64	do	197.1	do	223.7	15.62	3,494
	9	Check	4.48	do	204.6	Dec. 10	240.4	16.77	4,032
	10	Colonized	2.53	Nov. 2	154.1	Nov. 13	159.3	15.59	2,483
	10	Buffer	5.02	do	162.4	do	183.3	15.79	2,894
	10	Check	2.34	do	180.6	do	180.5	15.92	2,396
Averages		Colonized	4.36		181.6		193.7	14.55	2,818
		Buffer	5.77		180.1		202.2	14.53	2,938
		Check	3.84		182.4		195.4	14.88	2,906
Average of all experiments, Houma and Jeanerette in 1934.		Colonized	4.11		166.7		176.5	15.17	2,677
		Buffer	5.66		167.0		180.0	15.57	2,804
		Check	3.79		168.4		178.0	15.30	2,723

HOUMA EXPERIMENTS, 1935

P. O. J. 234, first stubble.	21	Colonized	1.52	Oct. 14	123.01	Oct. 24	168.3	15.32	2,578
	21	Buffer	6.83	do	137.79	do	171.1	15.20	2,616
	21	Check	2.65	do	157.50	Oct. 25	169.5	16.97	2,876
	22	Colonized	3.19	do	140.14	do	174.2	18.22	3,174
	22	Buffer	4.55	do	138.44	do	171.0	17.86	3,108
	22	Check	2.98	do	129.39	do	161.5	17.14	2,768
C. P. 807, first stubble.	23	Colonized	2.91	do	191.81	Oct. 20	143.4	22.13	3,173
	23	Buffer	5.96	do	138.56	Oct. 29	145.8	23.85	3,477
	23	Check	2.84	do	191.81	do	151.7	21.10	3,201
Co. 281, first stubble.	24	Colonized	6.87	Nov. 8	220.59	Jan. 7[1]	195.5	22.37	4,373
	24	Buffer	7.94	do	219.98	Jan. 8	184.3	23.51	4,333
	24	Check	4.21	do	215.60	Jan. 9	173.4	27.22	4,720
	25	Colonized	1.85	Oct. 31	184.53	Nov. 5	177.0	19.59	3,467
	25	Buffer	6.24	do	171.78	do	176.0	22.00	3,872
	25	Check	2.33	do	172.59	do	175.0	22.02	3,867
	26	Colonized	3.28	do	173.88	Nov. 2	162.0	22.56	3,655
	26	Buffer	6.13	do	162.17	do	178.0	22.17	3,946
	26	Check	4.76	do	175.19	do	168.7	21.28	3,547

[1] 1936.

TABLE 16.—*Yield of sugar and related data on the colonized, buffer, and check plots in the experiments on the mass liberations of Trichogramma minutum in Louisiana, 1933–35*—Continued

HOUMA EXPERIMENTS, 1935—Continued

Variety and crop	Plot No.	Treatment	Size of plot	96° sugar per ton of cane				Cane per acre	Sugar per acre based on factory analysis
				Small-mill analysis		Factory analysis			
				Date cut	Quantity	Date cut	Quantity		
			Acres		*Pounds*		*Pounds*	*Tons*	*Pounds*
Co. 281, plant	27	Colonized	2.20	Dec. 16	199.52	Jan. 2	173.9	34.58	6,013
	27	Buffer	3.23	do	190.18	Jan. 3	168.0	36.12	6,068
	27	Check	1.75	do	207.79	do	176.0	38.11	6,707
C. P. 807, first stubble	c30	Colonized	2.62	Oct. 17	146.21	Oct. 30	158.7	25.80	4,094
	c30	Buffer	5.06	do	151.10	Oct. 29	159.0	25.74	4,093
	c30	Check	2.21	do	154.52	do	156.1	25.60	3,996
Co. 281, first stubble	c31	Colonized	3.61	Nov. 7	213.81	Nov. 29	208.6	19.28	4,022
	c31	Buffer	5.02	do	203.22	Nov. 30	200.2	20.23	4,050
	c31	Check	4.81	do	208.65	do	182.5	22.39	4,086
	c32	Colonized	1.09	do	212.29	Nov. 29	203.9	18.24	3,719
	c32	Buffer	3.74	do	211.59	Nov. 28	206.1	16.93	3,489
	c32	Check	2.57	do	207.53	do	203.0	17.22	3,582
	c33	Colonized	1.35	do	217.88	Nov. 27	224.9	16.38	3,684
	c33	Buffer	2.31	do	235.38	do	217.5	18.31	3,932
	c33	Check	1.09	do	235.48	Nov. 28	218.7	18.57	4,061
Averages		Colonized	2.77		183.95		180.9	21.32	3,857
		Buffer	5.18		176.19		180.0	22.00	3,960
		Check	2.91		186.97		176.3	22.51	3,969

JEANERETTE EXPERIMENTS, 1935

Co. 290, plant	3	Colonized	4.39	Oct. 31	170.6	Dec. 2	198.6	35.52	7,054
	3	Buffer	4.35	do	173.5	Dec. 4	200.9	36.63	7,359
	3	Check	4.97	do	175.3	do	198.7	35.44	7,042
	4	Colonized	3.99	Nov. 1	191.0	Dec. 7	222.3	32.12	7,140
	4	Buffer	3.24	do	193.7	do	226.9	32.28	7,324
	4	Check	2.63	do	197.9	do	197.8	31.73	6,276
Co. 281, first stubble	7	Colonized	2.96	Oct. 15	130.5	Dec. 9	220.2	27.66	6,091
	7	Buffer	3.14	do	139.4	Dec. 7, 9	218.7	23.62	5,168
	7	Check	3.05	do	142.1	Dec. 7	221.9	23.42	5,197
P. O. J. 213, plant	8	Colonized	4.65	Oct. 25	173.8	Nov. 18	206.3	22.34	4,609
	8	Buffer	8.64	do	180.2	do	198.5	21.43	4,254
	8	Check	4.30	do	189.4	Nov. 19	207.8	17.84	3,707
	10	Colonized	2.86	Oct. 28	153.0	Dec. 21	216.3	21.75	4,704
	10	Buffer	4.99	do	170.0	do	211.0	23.71	5,002
	10	Check	2.96	do	166.5	do	224.5	24.78	5,563
Co. 290, first stubble	c13	Colonized	2.74	Nov. 5	135.7	Dec. 23	213.8	37.36	7,987
	c13	Buffer	4.56	do	180.4	Dec. 21	216.3	37.24	8,055
	c13	Check	2.80	do	176.7	do	206.4	41.78	8,623
Co. 281, first stubble	14	Colonized	2.99	Oct. 15	148.7	Dec. 24	199.3	25.43	5,068
	14	Buffer	3.05	do	150.8	Dec. 23, 24	204.4	24.10	4,926
	14	Check	3.09	do	151.3	Dec. 23	194.1	22.69	4,385
Co. 281, second stubble	c19	Colonized	2.73	Nov. 4	205.9	Dec. 26	228.8	25.26	5,779
	c19	Buffer	8.10	do	196.1	do	221.3	25.57	5,660
	c19	Check	2.73	do	190.2	do	226.3	27.69	6,312
Co. 281, first stubble	c20	Colonized	2.94	Nov. 5	188.3	Dec. 28	184.6	26.48	4,888
	c20	Buffer	5.77	do	200.6	Dec. 27, 28	209.1	25.60	5,353
	c20	Check	2.93	do	193.0	Dec. 27	197.7	26.48	5,235
Average, Jeanerette		Colonized	3.36		175.8		210.0	28.21	5,924
		Buffer	5.09		176.1		211.9	27.91	5,914
		Check	3.27		174.8		203.3	27.99	5,830
Average, Jeanerette and Houma in 1935		Colonized	3.04		180.28		194.0	24.42	4,737
		Buffer	5.14		177.26		194.6	24.66	4,799
		Check	3.07		181.49		190.7	24.98	4,764

The yield data on the experiments of 1934 are tabulated in a form similar to those of 1933 except that the data for the Houma and Jeanerette areas are given separately, although averaged together. It is apparent that in terms of sugar per acre the colonized areas led at Jeanerette in experiments 7 and 9, and at Houma in experiments 4, 5, and 10. The check areas led in 1 and 4 at Jeanerette, and in 2, 3, and 9 at Houma. The other experiments gave more sugar per acre in the buffer plots. There were five experiments in favor of the colonized areas, five in favor of the checks, and eight in favor of the buffers. In comparing the combined averages, it is shown that this year the check plots again surpassed the colonized plots, leading by 46 pounds of sugar per acre. However, the buffers again produced more sugar per acre than either the colonized or the check plots.

In 1934, during the rush of the late harvest season, the plantation managers failed to notify the Bureau representative that they were harvesting experiment 5 at Jeanerette, and consequently weights of the cane and sugar on these plots were not obtained. The indications were that these might have been in favor of the colonized area. Jeanerette experiment 6 was cut for seed cane and weights were not obtained on this area. There would likely have been little difference between the check and colonized areas in this experiment. In harvesting Jeanerette experiment 7, the colonized area was harvested on December 12 and 13 and hauled on December 13 and 14, whereas the buffer and check plots were not cut until December 17 and 18 and were hauled on December 19. Since there was a killing freeze on December 11, the delay in harvesting no doubt caused a reduction in sugar per ton of cane, and possibly in weight, from the buffer and check plots, since the stalks were cut lower at the tops to avoid harvesting sour cane. A comparison of the gain in sugar in the various plots between the time of the small-mill analyses and the factory analyses indicated that there was a loss in sucrose on account of the delay.

In 1934 Houma experiments 1 and 2 were harvested after the freeze of December 11, and there was no doubt a reduction in sugar per ton, as the yield-data table shows that there was less sugar at the time the factory samples were taken than at the time of the small-mill samples, in contrast to practically all the other experiments. In experiment 1 all the cane was windrowed prior to the freeze and should have suffered little deterioration. Furthermore, all this cane was milled within 2 days, and should have been comparable. In experiment 2 a part of the colonized plot was harvested last, which may have been disadvantageous. It is thought, however, that the data from these two experiments are reliable enough to show that there had been no advantage in releasing the parasites. These two experiments were carried on in cooperation with the Louisiana Agricultural Experiment Station.

In 1935, on the basis of sugar per acre, the colonized area led in four experiments, the buffer in four experiments, and the check in six experiments. In the remaining six experiments the yields of two or more of the areas were practically equal.

Four experiments were windrowed in 1935. Experiment 20 was windrowed on November 22 and 24 and harvested on December 27 and 28. Experiments 7 and 14 were windrowed on November 25 and 27, and on December 6 the cane caught on fire. All the cane in

experiment 7 except 7–P, cut 1, was burned. In experiment 14 only 14–C, cut 1, and a part of 14–C, cut 2, were burned. This burnt cane was topped in the next 2 days and hauled. The sucrose test on the cane in 7–P, cut 1, could not be used, as this cane was harvested 20 days after the burned cane. In experiment 14 only the test made on the unburned cane was used. Experiment 24 was windrowed on December 5 and harvested on January 8. Except where there was a time difference in harvesting, windrowing apparently did not affect the reliability of the experiments.

Explanations should be made concerning experiments 7, 8, and 14 of 1935 in the Jeanerette area, in which the yields of the colonized areas exceeded the checks by 3 to 4½ tons of cane per acre. Experiment 14 was included in the burned area. In 1934, 7–P had been the check plot and that year it produced nearly 1½ tons of cane per acre more than the colonized plot. The various cuts used in experiment 8 were supposed, according to the overseer, to have been comparable from past yields, but at the end of the season both the manager and overseer of the plantation remembered that the two cuts used for the check a'ways gave a little less tonnage. The sugar per ton of cane was higher in the check since the cane was more mature than in the colonized area, but not enough more to offset the increase in tonnage of cane produced in the colonized area.

In experiment c13, in Co. 290, first-year stubble, there was undoubtedly a soil difference or some other factor not connected with borer damage that caused the yield in the check to be so much higher than that in the buffer or colonized areas.

The factory sucrose test on the colonized area of experiment 20 (Jeanerette, 1935) appears to be lower than it should have been. In this experiment the loads for the sucrose test from the buffer and check areas were milled during the afternoon, and six test loads from the colonized area were set aside to be run through the following morning, but the truck driver failed to get a sucrose test on them. Additional test loads were taken the next morning, but as there had been a heavy rain the night before, the cane was wet and muddy. This condition probably caused a decrease in the sucrose when the juice was analyzed.

In the experiments conducted cooperatively with the Louisiana Agricultural Experiment Station in 1935, the pounds of sugar per acre was highest in the colonized area in one experiment, in the buffer in one, and in the check area in two experiments. The remaining three experiments showed two or more of the areas practically even in sugar per acre. Five of the seven cooperative experiments had a borer infestation of over 20 percent of the joints bored in one of the plots, and another experiment had an infestation of 18.7 percent in one of the plots. The cooperative experiments showed results no more in favor of the colonized areas than did the other experiments conducted during the three seasons.

Differences in yields occur normally between the most nearly uniform areas obtainable and would be expected if no treatment had been given any of the plots. No relationship was evident, however, between *Trichogramma* releases and increased yields; yet such a relationship certainly should have appeared, in the large number of experiments conducted, had this practice resulted in any significant increase in yield.

Yield and Sucrose Variation Within Certain Fields

In some of the experiments there was a greater difference in yield between the two or three cuts composing the colonized plot than there was between the average of the colonized and the average of the check cuts of the same experiment. For instance, in 1934, in an experiment in the Houma area (table 17), there was a difference of 1,308 pounds of sugar per acre between the highest and lowest yields of the three cuts composing the colonized plot. There was a difference of 1,166 pounds between the highest and lowest yields of the cuts of the buffer plot, and in the check a difference of 77 pounds between the highest and lowest cuts. Yet there was a difference of only 49 pounds between the average yield of the colonized plot and the average yield of the check plot. The great increase in yield per acre in both the high-yielding cut in the colonized plot and the high-yielding cut in the buffer over the other cuts in the same plots was due in both instances to a slightly higher yield of cane per acre and a considerably higher sucrose analysis of the cane. This shows very clearly the advantage of taking the yield for each cut and also a separate sucrose analysis from each cut and averaging the results from all the cuts in each plot, rather than to depend upon one analysis for the entire plot which might consist of two or three cuts. As has been stated, this method was followed in all the experiments in 1934 and 1935.

Table 17.—*Variation in yield by cuts in a Trichogramma experiment plot at Houma, La., 1934*

Plot treatment	Cut No.	Size of cut	Cane per acre	Yield of 96° sugar per—	
				Ton of cane	Acre
		Acres	*Tons*	*Pounds*	*Pounds*
Colonized	1	2.133	25.54	119.91	3,062
	2	1.562	25.70	128.07	3,291
	3	1.660	26.35	166.46	4,370
Average			25.83	138.15	3,568
Buffer	1	1.513	27.61	161.26	4,452
	2	2.113	25.80	139.21	3,592
	3	1.882	24.60	133.57	3,286
Average			26.00	144.68	3,762
Check	1	1.752	24.73	141.86	3,508
	2	1.609	23.06	151.00	3,482
	3	1.727	24.70	144.10	3,559
Average			24.16	145.65	3,519

To determine the variation in canefields that were considered as nearly uniform as could be obtained, heap-row records were taken in certain fields in 1934. When the cane was harvested, the cane from three to five adjoining rows was piled together in one continuous heap row. A record was kept of the weight of cane in each heap row, and a sugar analysis was obtained for each cut in four experiments in the Houma area. The variation in the number of pounds of sugar per acre obtained per heap row for each cut in three of these experiments

is shown in figure 4. The variation within each cut is due entirely to cane tonnage per acre, as only one analysis for sugar was obtained per cut.

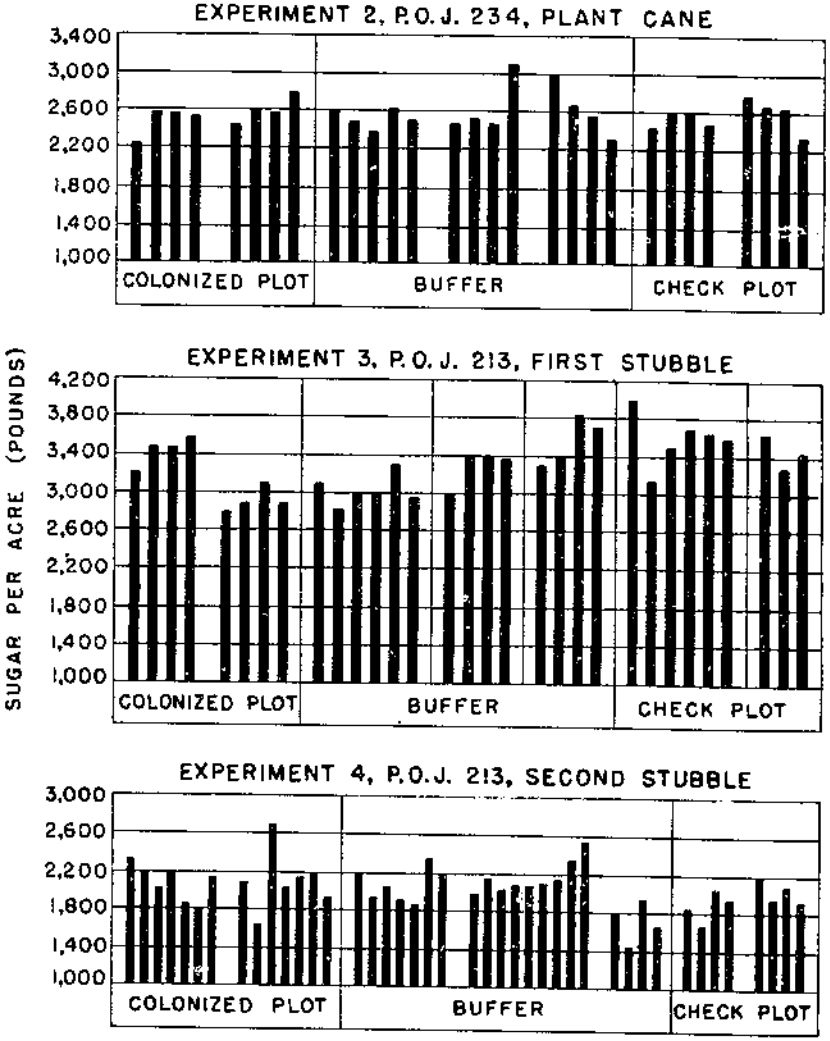


FIGURE 4.—Pounds of sugar per acre in the various heap rows for each cut in the colonized (parasite), buffer, and check plots in three experiments in 1934. Each vertical bar represents the yield of a heap row.

A record of the weight of cane on each heap row in six experiments was obtained in 1935 and from these weights the sugar per heap row was calculated by using the sucrose analyses for the cut in which the heap row occurred. These data are given in table 18.

TABLE 18.—*Yield of sugar per acre from individual heap rows in six experiments at Houma, La., 1935*

Plot treatment	Cut No.	Heap row	Experiment 22, P. O. J. 234, stubble	Experiment 23, C. P. 807, stubble	Experiment c30, C. P. 807, stubble	Experiment c31, Co. 281, stubble	Experiment c32, Co. 281, stubble	Experiment c33, Co. 281, stubble
			Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
		a	3,208	3,330	4,481	3,934	3,793	3,508
		b	3,430	2,821	4,842	3,544	3,364	3,261
		c	3,554	2,813	3,826	4,364	3,956	3,980
		d	3,277	2,963	3,715	3,749	----------	2,991
	1	e	3,082	3,276	4,111	----------	----------	----------
		f	----------	3,308	----------	----------	----------	----------
		g	----------	3,315	----------	----------	----------	----------
Colonized		h	----------	3,544	----------	----------	----------	----------
		a	2,849	----------	----------	4,650	----------	----------
		b	2,490	----------	----------	4,119	----------	----------
	2	c	3,412	----------	----------	3,716	----------	----------
		d	3,011	----------	----------	5,075	----------	----------
		e	3,110	----------	----------	----------	----------	----------
		a	3,354	3,470	4,815	4,533	3,261	3,708
		b	3,996	3,210	4,336	4,325	3,364	4,445
	1	c	3,360	3,616	3,920	4,366	4,225	3,795
		d	2,915	3,245	4,128	4,866	----------	----------
		e	----------	3,407	----------	----------	----------	----------
		a	3,110	3,928	4,193	4,619	4,180	4,407
		b	3,119	3,056	4,066	4,784	2,739	3,774
		c	3,386	3,679	4,272	4,227	3,418	3,490
Buffer	2	d	3,048	3,253	----------	----------	3,624	3,970
		e	----------	3,579	----------	----------	----------	----------
		f	----------	3,420	----------	----------	----------	----------
		g	----------	3,521	----------	----------	----------	----------
		h	----------	3,913	----------	----------	----------	----------
		a	3,163	----------	3,179	3,098	3,317	----------
		b	3,127	----------	3,794	2,799	3,586	----------
	3	c	3,113	----------	3,810	2,538	4,022	----------
		d	3,223	----------	----------	3,863	3,959	----------
		a	2,828	3,463	4,230	3,412	3,147	4,134
		b	3,043	3,335	3,668	4,345	2,984	4,200
	1	c	3,347	----------	4,494	3,396	3,617	3,916
		d	2,817	----------	4,652	3,030	4,046	----------
		e	2,448	----------	----------	----------	----------	----------
Check		a	2,545	3,267	----------	----------	3,536	----------
		b	3,029	2,807	----------	----------	2,879	----------
	2	c	2,732	3,399	----------	----------	5,272	----------
		d	2,780	3,424	----------	----------	----------	----------
		e	----------	2,174	----------	----------	----------	----------

In 1935 a sucrose analysis was made of the cane from each railroad car from three cuts at Reserve Plantation. All the cane in each cut received the same treatment in cultivation, colonization, and harvesting. All the cane was hauled without delay and sucrose analyses were all made on the same date. Table 19 shows a difference of 18.95 pounds of sugar per ton of cane between the highest and the lowest test car in experiment c30–C, cut 1; of 15.27 pounds in c30–B, cut 1; and of 15.68 in c30–B, cut 2. From this it may be seen that there is considerable difference in the yield of sugar per ton of cane from different carloads from the same cut. Thus the difference between small samples can be expected to vary as much if not more. If 3 or 4 carloads were used for a composite sample for each cut, this error or variation in sampling would be reduced.

TABLE 19.—*Results of sucrose analyses made on individual carloads of C. P. 807 first stubble cane at Reserve, La., Oct. 29, 1935*

Experiment, plot No., and cut	Car No.	Weight of cane	Yield of 96° sugar per ton of cane
		Pounds	*Pounds*
c30-C, cut 1	114	12,200	158.87
	141	11,800	155.72
	183	12,040	160.72
	121	11,320	155.52
	152	10,360	155.94
	109	8,400	148.21
	139	13,880	158.03
	105	11,920	158.45
	82	11,580	156.25
	13	7,620	153.83
	81	2,180	167.16
Average			157.15
c30-B, cut 1	1	10,980	162.54
	36	13,440	154.09
	171	13,120	162.09
	73	13,120	152.15
	91	11,180	147.27
	221	13,460	155.55
	180	12,940	152.17
	212	12,980	151.11
	154	5,240	149.34
Average			154.04
c30-B, cut 2	227	13,460	155.22
	4	13,840	159.48
	72	14,120	155.94
	199	11,460	153.80
	31	11,120	163.76
	177	13,320	155.51
Average			158.95

SUMMARY OF EXPERIMENTS CONDUCTED IN COOPERATION WITH THE LOUISIANA AGRICULTURAL EXPERIMENT STATION

During 1934 only two cooperative experiments were carried on with the Louisiana Agricultural Experiment Station, but in 1935 the number was increased to seven. The fields for all the cooperative experiments were selected jointly with a representative of the experiment station and with the assistance of A. M. O'Neal, associate soil technologist of the Bureau of Plant Industry and officials of the sugar companies on whose properties the experiments were conducted. These fields were selected with the greatest possible care, to get the areas most comparable as to soil type, fertility, stand, size of cane, and past treatment. The parasites were furnished by both cooperators and released at a time agreeable to both. The egg examinations and infestation counts were made both jointly and independently by both cooperators. A representative of one or both was present at the time the experiments were harvested to obtain yield data.

In 1934, parasites were released in the 2 cooperative experiments during June at the rate of 11,950 per acre in c1 and 9,241 per acre in c2. During June, July, and August a total of 17,930 parasites were released per acre in c1, and 18,700 parasites were released per acre in c2.

Collections of borer eggs were made in both cooperative experiments during April, June, July, August, and September. The first parasitized eggs found in the cooperative experiments were collected

from the check in c1 on June 26. The final percentage of parasitization averaged only slightly higher in the colonized plots than in the checks.

Infestation counts were made on at least 200 stalks in each of the colonized, buffer, and check plots of both experiments. The percentage of bored joints was somewhat higher in the colonized than in the check plots. The infestation counts are given in table 12. As shown in table 15, *Trichogramma* releases neither increased the percentage of millable stalks nor decreased the borer infestation in unmillable plants in the six cooperative experiments in which these data were obtained.

The cane in all three plots of c1 was windrowed and harvested at approximately the same time. In the colonized plot of c1 the yield of sugar per acre was 55 pounds higher than for the check, but in the buffer it was more than 100 pounds higher than in the colonized or check plots. In c2 the yield of sugar in the colonized plot was less than for the buffer or check plots of the same experiment (table 16).

Parasites were released in 3 of the cooperative experiments during June 1935 at a rate higher than 5,000 per acre. The number of parasites released in all seven during June, July, and August averaged between 15,000 and 43,000 per acre. The information on the parasite releases is given in table 7.

The percentage of parasitization in the colonized plots of c13, c19, and c20 did not average so high during July as in the buffers and checks. Late in August and during September the parasitization in the colonized, buffer, and check plots was about the same. In the four other cooperative experiments parasitized eggs were found during the latter part of July in the plot intended to be used as the check of c30, where the average parasitization was 21.7 percent, and in the plot to be colonized and the buffer plot in c31, where it was 26.1 and 58.1 percent, respectively, before any releases were made. No parasitization was found during July in c32 or c33. During the latter part of August and in September the parasitization in these four experiments averaged about the same.

The percentage of bored joints in c13, c19, and c20, where parasites were released in June, averaged about the same for the colonized, buffer, and check plots. In the four experiments, where the releases were made during August, the percentage of bored joints was about the same in two experiments and slightly in favor of the colonized in one experiment and in the check in the other. The data on the infestation counts are given in table 12.

The yield of sugar per acre in the three experiments where the parasites were released in June was slightly higher in the checks than in the colonized plots. In the four that received the parasites in August the yield of sugar was about the same in two, slightly in favor of the colonized in one, and considerably in favor of the check plot in the other. The yield data are given in table 16.

The results of the cooperative experiments do not show any consistent gain in favor of the colonized plots. The percentage of parasitization, number of bored joints, and yield of sugar per acre averaged about the same for the nine experiments that were conducted during 1934 and 1935.

SUMMARY AND CONCLUSIONS

Experiments were conducted for three seasons to ascertain whether or not the sugarcane borer (*Diatraea saccharalis* (F.)) could be controlled in Louisiana by mass liberations of *Trichogramma minutum* Riley.

Several lots of bagworm eggs were placed in the field during the winter and early part of spring, but no parasitization by *Trichogramma* was obtained. A *Trichogramma* adult, however, was collected in the winter, and several species of moths were found depositing eggs at this time which could serve as hosts.

Experiments conducted in April 1934 showed that *Trichogramma* dispersed as far as 100 feet within 48 hours after release.

It was apparent from a comparison of the numbers of joints bored externally and internally that the count of joints bored externally can be used as a reliable indication of the actual internal borer injury.

A definite correlation is shown between the percentage of parasitization and host density. A study of egg collections and of the correlation between parasitization and host density indicates that very little reliability can be placed on the increase of parasitization prior to August as an indicator of sugarcane borer control.

Every precaution was taken to see that the plots selected for the experiments on the control of the borer by the mass liberation of *Trichogramma* were uniform in every respect. Each experiment consisted of a colonized and a check area which were separated by a buffer area in 1934 and 1935 and in most cases in 1933. Parasites were released at the rate of from 10,000 to 45,000 per acre during the 3 seasons.

In comparing the progress of parasitization of the borer egg clusters found throughout the three seasons, very little difference was observed between the percentages of parasitization in the colonized, buffer, and check plots.

A study of the infestations in the stalk and joint showed that the borer infestation in the plots in which *Trichogramma* parasites were released increased to as great an extent as in the check plots.

Factory analyses for sugar content and the net weight of all th cane harvested from each plot was used to obtain the amount of sugar and cane produced per acre in the various plots. No relationship was evident between *Trichogramma* releases and increased yields; yet such a relationship certainly should have appeared, in the large number of experiments conducted, had this practice resulted in any significant increase in yield.

In some experiments the difference in yield between the two or three cuts composing the colonized plot was greater than that between the average of the colonized and the average of the check cuts of the same experiment. There was also considerable variation in the pounds of sugar per ton of cane resulting from tests made on various carload lots of cane from the same cut. These differences indicate the great variation in yield that occurs in the average cut of sugarcane.

Thus, the results of the experiments conducted during the three seasons show that releases of *Trichogramma minutum* are of no value in the control of the sugarcane borer in Louisiana. The colonization of *Trichogramma* as a field practice for the control of the sugarcane borer is therefore not recommended.

LITERATURE CITED

(1) ALLEN, H. W., and WARREN, A. J.
1932. THE RESULTS FROM TWO YEARS' EXPERIMENTS IN MASS LIBERATIONS OF TRICHOGRAMMA MINUTUM AGAINST THE ORIENTAL FRUIT MOTH. Jour. Econ. Ent. 25: 374–380, illus.

(2) CLAUSEN, CURTIS P.
1935. INSECT PARASITES AND PREDATORS OF INSECT PESTS. U. S. Dept. Agr. Cir. 346, 22 pp., illus.

(3) CLEARE, L. D., JR.
1929. MOTH BORER CONTROL IN BRITISH GUIANA. 4th Internatl. Cong. Ent. Trans., pp. [131]–137.

(4) ———
1934. SUGAR-CANE MOTH-BORER INVESTIGATIONS IN BRITISH GUIANA: THE PRESENT POSITION. Agr. Jour. Brit. Guiana 5 (1): [13]–21.

(5) FLANDERS, S. E.
1929. THE MASS PRODUCTION OF TRICHOGRAMMA MINUTUM RILEY AND OBSERVATIONS ON THE NATURAL AND ARTIFICIAL PARASITISM OF THE CODLING MOTH EGG. 4th Internatl. Cong. Ent. Trans., pp. [110]–130, illus.

(6) HINDS, W. E., OSTERBERGER, B. A., and DUGAS, A. L.
1933. REVIEW OF SIX SEASONS' WORK IN LOUISIANA IN CONTROLLING THE SUGAR CANE MOTH BORER BY FIELD COLONIZATIONS OF ITS EGG PARASITE TRICHOGRAMMA MINUTUM RILEY. La. Agr. Expt. Sta. Bul. 235, 36 pp., illus.

(7) ——— OSTERBERGER, B. A., and DUGAS, A. L.
1934. SUGAR CANE MOTH BORER CONTROL BY TRICHOGRAMMA MINUTUM RILEY. REPORT ON EXPERIMENTAL WORK FOR 1933. La. Agr. Expt. Sta. Bul. 248, 34 pp., illus.

(8) ——— and SPENCER, HERBERT.
1928. UTILIZATION OF TRICHOGRAMMA MINUTUM FOR CONTROL OF THE SUGARCANE BORER. Jour. Econ. Ent. 21: 273–279, illus.

(9) ——— and SPENCER, HERBERT.
1930. PROGRESS IN THE UTILIZATION OF TRICHOGRAMMA MINUTUM IN CANE BORER CONTROL IN LOUISIANA DURING 1929. Jour. Econ. Ent. 23: 121–127.

(10) JAYNES, H. A., and BYNUM, E. K.
1936. A PRELIMINARY REPORT ON THE USE OF THE EGG PARASITE TRICHOGRAMMA MINUTUM RILEY FOR THE CONTROL OF THE SUGARCANE BORER. Sugar Bul. 14 (19): 1–4.

(11) LIST, GEO. M., and DAVIS, L. G.
1932. THE USE OF TRICHOGRAMMA MINUTUM (HYMENOPTERA CHALCIDIDAE) RILEY IN THE CONTROL OF THE CODLING MOTH IN COLORADO. Jour. Econ. Ent. 25: 981–985.

(12) PETERSON, ALVAH.
1930. A BIOLOGICAL STUDY OF TRICHOGRAMMA MINUTUM RILEY AS AN EGG PARASITE OF THE ORIENTAL FRUIT MOTH. U. S. Dept. Agr. Tech. Bul. 215, 22 pp., illus.

(13) SCHREAD, J. C.
1935. COOPERATIVE EUROPEAN CORN BORER EGG PARASITISM INVESTIGATION. Conn. Agr. Expt. Sta. Bul. 383: 344–346, illus.

(14) ——— and GARMAN, PHILIP.
1933. STUDIES ON PARASITES OF THE ORIENTAL FRUIT MOTH, I. TRICHOGRAMMA. Conn. Agr. Expt. Sta. Bul. 353: 691–756, illus.

(15) SMYTH, E. GRAYWOOD.
1933. TECHNIQUE IN THE MASS PRODUCTION OF TRICHOGRAMMA. Jour. Econ. Ent. 26: 768–774, illus.

(16) TUCKER, R. W. E.
1935. A REVIEW OF CONTROL WORK ON DIATRAEA SACCHARALIS F. IN BARBADOS. Internatl. Soc. Sugar Cane Technol. Cong. Proc. 5: 386–397.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE WHEN THIS PUBLICATION WAS LAST PRINTED

Secretary of Agriculture	CLAUDE R. WICKARD.
Under Secretary	PAUL H. APPLEBY.
Assistant Secretary	GROVER B. HILL.
Director of Information	MORSE SALISBURY
Director of Extension Work	M. L. WILSON.
Director of Finance	W. A. JUMP.
Director of Personnel	ROY F. HENDRICKSON.
Director of Research	JAMES T. JARDINE.
Director of Marketing	MILO R. PERKINS.
Solicitor	MASTIN G. WHITE.
Land Use Coordinator	M. S. EISENHOWER.
Office of Plant and Operations	ARTHUR B. THATCHER, *Chief.*
Office of C. C. C. Activities	FRED W. MORRELL, *Chief.*
Office of Experiment Stations	JAMES T. JARDINE, *Chief.*
Office of Foreign Agricultural Relations	LESLIE A. WHEELER, *Director.*
Agricultural Adjustment Administration	R. M. EVANS, *Administrator.*
Bureau of Agricultural Chemistry and Engineering.	HENRY G. KNIGHT, *Chief.*
Bureau of Agricultural Economics	H. R. TOLLEY, *Chief.*
Agricultural Marketing Service	C. W. KITCHEN, *Chief.*
Bureau of Animal Industry	JOHN R. MOHLER, *Chief.*
Commodity Credit Corporation	CARL B. ROBBINS, *President.*
Commodity Exchange Administration	JOSEPH M. MEHL, *Chief.*
Bureau of Dairy Industry	O. E. REED, *Chief.*
Bureau of Entomology and Plant Quarantine	LEE A. STRONG, *Chief.*
Farm Credit Administration	A. G. BLACK, *Governor.*
Farm Security Administration	C. B. BALDWIN, *Administrator.*
Federal Crop Insurance Corporation	LEROY K. SMITH, *Manager.*
Forest Service	EARLE H. CLAPP, *Acting Chief.*
Bureau of Home Economics	LOUISE STANLEY, *Chief.*
Library	RALPH R. SHAW, *Librarian.*
Bureau of Plant Industry	E. C. AUCHTER, *Chief.*
Rural Electrification Administration	HARRY SLATTERY, *Administrator.*
Soil Conservation Service	H. H. BENNETT, *Chief.*
Surplus Marketing Administration	MILO R. PERKINS, *Administrator.*

This bulletin is a contribution from

Bureau of Entomology and Plant Quarantine	LEE A. STRONG, *Chief.*
Division of Cereal and Forage Insect Investigations.	C. M. PACKARD, *Principal Entomologist, in Charge.*

U. S. GOVERNMENT PRINTING OFFICE: 1941

For sale by the Superintendent of Documents, Washington, D. C. - - - - - - - - - Price 10 cents

END