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BUREAU OF SUGAR EXPERIMENT STATIONS.

Smithsonian Institution
APR 29 1919
National Museum.

DIVISION OF ENTOMOLOGY.
BULLETIN No. 7.

Monthly Notes on Grubs and other Cane Pests.

BY

J. F. ILLINGWORTH.

1917-1918.

BRISBANE:
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Bureau of Sugar Experiment Stations,
Brisbane, 15th March, 1919.

The Under Secretary,
Department of Agriculture and Stock, Brisbane.

Sir,—I have the honour to submit, for publication as Bulletin No. 7 of the Division of Entomology of the Bureau of Sugar Experiment Stations, a series of Monthly Notes on the Grub and other Cane Pests, by Dr. J. F. Illingworth.

I have, &c.,
HARRY T. EASTERBY, General Superintendent.

Approved: E. G. E. Scriven, Under Secretary.

Monthly Notes on Grubs and other Cane Pests.

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INTRODUCTION.

Any information upon the subject of white grubs is of such far-reaching importance that it should be readily available in every sugar-growing country. Furthermore, these notes, though they have appeared in scattered publications of the State, are here presented in a combined form, more accessible to our own growers, and more adaptable to filing in libraries. It is considered best to present them in their original form, as they were prepared, month by month, so that the progress of the investigation may be noted.

As soon as I was able to make a brief survey of the situation, after my arrival in Queensland, I outlined the following questions, seeking information from experienced growers. These were published in the "Australian Sugar Journal," August and September, 1917:—

(1) How long is newly-cleared scrub land free from grub attack?

(2) Have you any experience with Mauritius bean as a green manure following failure of the cane crop?

(3) Have you used any other form of green manure successfully?

(4) Have you any land that is now free from grubs that was formerly infested?

(5) Have you had any experience in ploughing under the trash on infested land?

(6) Have you any experience in the treatment of infested land with nitrate of soda or other chemical fertilisers?

(7) What is your experience in the treatment of infested land with meatworks manure?

(8) Have you any experience in the treatment of infested land with stable manure?

(9) Have you any experience in late planting on infested soils—say, December?

(10) Have you ever known grubs to attack cane on forest land?

I hoped from the answers to these questions to compile a lot of valuable information, which might aid us materially in our study of cane grubs and their control. I was disappointed in the result, however, for, as I have since learned, the more intelligent grower does not

place a sufficient value upon his own experience, especially when he is asked to sit down and write it out. I only got two replies to the questions, but these contained so many suggestions that it is a pity that they could not have been multiplied by hundreds.

Much of the information in the following pages, dealing with control measures, is credited to experienced growers in the various districts that I have visited; and they have my grateful appreciation, for they have enabled me to verify more quickly the several lines of treatment that I have suggested in my earlier reports:—

CANE GRUB INVESTIGATION, AUGUST, 1917.

Though we have been handicapped to date by a lack of transportation facilities, we have managed to get about somewhat, making observations with regard to the various factors determining the degree of grub infestation in the region about Gordonvale.

The tremendous importance of the problem impresses one at once upon viewing the great areas laid waste in districts like Meringa or Greenhills. Apparently there is no easy road to success in combating such a pest. Introduction of parasites will probably be of little avail, since we are here dealing with native insects. It is a well-understood fact that introduced parasites have only been used successfully against introduced pests. The fact of the matter is, we already find a number of parasitic and predaceous insects working against the grubs, but they are unable to show any marked results because they are themselves attacked by other parasites. There are, however, bacteria and parasitic fungi doing efficient work in some fields, especially under proper conditions of moisture, &c. Our excavations at Greenhills would indicate that approximately one-third of the grubs succumb to these organisms. We have not yet been able to determine how widely these friendly agents are distributed in the infested districts; but they certainly lend themselves to artificial propagation and transplanting, so that no field needs to be without them.

In testing the soils of badly-infested fields, they were all found to be very poor in humus, and usually contained no lime—two factors which would appear to be of vital importance to the growth of sugar-cane in a grub district. First, the main food of the grubs is decomposing organic matter in the soil, which, if it is lacking, forces them to feed upon living roots of plants. Secondly, lime not only improves the character of the soil by hastening the humification of plant tissues, and making it possible for leguminous plants to store up a cheap and abundant supply of nitrogen, but its action is also very favourable to the development of the fungous parasites. It is a well-known fact that neither organisms of decay nor disease-forms will develop well in acid soils—*i.e.*, soils containing no lime.

Apparently the general custom in all the grub districts has been to destroy the principal humus-forming elements by burning all the trash and failing to rotate cane with a green crop. So far we have only discovered one farmer who is working his land along the lines that science would suggest, and it is interesting to note that his farm, though originally rather poor land, is now among the best in the region about Gordonvale. Furthermore, he is not troubled with grubs, though the cane on near-by farms went down because of them. Moreover, this particular farm has better soil to-day than when it was opened up about twenty years ago. As to the treatment: the land was given a dressing of lime at the rate of about 1 ton per acre. A crop of beans was then turned under, preparatory to planting cane. After two ratoons and ploughing in all the trash another crop of beans was worked into the soil, and in addition about 5 cwt. of meatworks manure per acre. This rotation has been followed up, with the result that our tests now show an abundant supply of humus. Recently with the addition of about 2 cwt. of nitrate of soda per acre this land has shown remarkable results. The crop is easily 50 per cent. better than that of the adjoining farm, which was planted at the same time. I must not neglect to add that this farmer cultivates well, which is not only an important factor in plant development, but may be shown to have considerable bearing upon grub control. This control would come about through the conservation of soil moisture, which would not only stimulate the growth of the cane, making it more resistant to the attacks of grubs, but the conserved moisture would also be of material assistance to the development of fungous organisms destructive to the grubs. These parasites cannot work in dry soil, hence it is a well-recognised fact that grubs are most destructive in a dry season or upon dry soils.

The action of nitrate of soda or sulphate of ammonia is a marked stimulation of plant-growth and root-development, which makes the cane more resistant to the attack of grubs. Where there is a rapid renewing of roots as they are eaten off by grubs, the cane is able to hold its footing, and does not go down before the winds. This point was well illustrated in one field that we visited, a part of which had been treated with about 2 cwt. of sulphate of ammonia per acre. The cane of part of the field was all down, while right to the line in the treated plot it stood erect and vigorous. The untreated portion could not be ratooned, because all the stools were too much out of the ground.

As far as our observations have gone, the indications are that high-lying fields are attacked worse than those on low-lying ground. This may be explained upon the ground of weathering. Naturally, both humus and lime are leached out of high-lying soils, and tests show these soils to be very poor in both these elements.

The use of arsenious poisons for the destruction of the grubs, as suggested by Mr. Jarvis, is very promising. Since we already know

that they feed largely upon humus and decomposing soil substances, it would appear to be simply a matter of properly supplying and poisoning these organic bodies in the soil preparatory to cane planting. Fortunately, humus shows a marked affinity for arsenic, which has a defloculating action upon soil, making it more retentive to moisture. Chemical tests of certain soils of Hawaii, which have been treated with arsenic for the destruction of weeds for the past five years, show that all of the poison has remained in the top 4 inches of soil, without injuring in any way the roots of the growing crop. If we can make use of arsenic as a weed-killer, and at the same time poison the food supply of the grubs, it will certainly be a profitable procedure.

Experiments are now being undertaken with 10 acres in one of the worst grub areas on Meringa Farm, in order to test out the various suggestions as outlined above. This land is divided up into fifteen plots, from which we hope to get some conclusive results.

It is rather early for us to make recommendations, but we should certainly say 'conserve the humus and apply lime.' Later we may be able to suggest the best method of poisoning the grubs. In the meantime make use of every known method of combating these terrible pests.

CANE GRUB INVESTIGATION, SEPTEMBER, 1917.

Though this is the slack season in the activities of the grubs, we have been very busy in framing up our lines for attack, when they do become active again. The following list will not only serve to illustrate the comprehensiveness of these lines, but it will also indicate clearly the necessity for considerable additional assistance, if they are to be soon carried out. This assistance will be referred to again later:—

1. A study of the distribution of species with relation to soil, timber, cultural methods, &c.
2. Mapping of infested and non-infested regions.
3. Morphological study of reproductive organs of beetles, with relation to the period of ovipositing, and the number of eggs produced.
4. Morphological study of the fungous parasites.
5. Breeding of the various local parasitic and predaceous insects in cages.
6. Introduction and breeding of beetle parasites from other countries.
7. Experimental methods for the rapid multiplication and wide distribution of our fungous parasites.
8. Introduction of bacterial and fungous enemies of the beetles from other countries.
9. A further study of various light-traps for the beetles.
10. A further study of repellents.

11. Field and laboratory experiments in the use of poisons for the grubs.
12. Field experiments to determine the relation of fertilisers to resistance; using green manure, stable manure, meat-works, nitrate of soda, &c.
13. A study of the effect of trash left on the field during the period of ovipositing of the beetles.
14. Also, having the ground covered with Mauritius beans during this period—planting cane in March.
15. Another experiment working the fallow soil during January and February, and planting in March.
16. Experiments in late planting—using plots planted in November and December, which are to be worked through the period of ovipositing.
17. Experiments to determine how far the beetles fly.
18. A study of varieties of cane best suited to grub resistance.
19. Experiments showing the value of lime on grub-infested soil.
20. Development of a general reference collection in the laboratory.

This list might be considerably extended, but, since several of the topics are so important that we might profitably occupy all of our time with one of them, it would appear best not to make the list too far-reaching. It is hoped, however, that we may soon have the assistance of a number of students, who, while they are carrying out investigations along these various lines, will be gaining in practical experience and power, which will inevitably prove of great worth, both to the State and to themselves. Pests of tropical crops are omnipresent, and the call for trained men to cope with them will ever be insistent. Certainly, the expenditure for the permanent equipment of our new Experimental Station could not be put to better use.

Some Recent Observations that will Prove of Interest.

Beetles were found, fully developed, in the soil at Greenhills, 4th July. These were in the hardest kind of soil, over 2 feet from the surface, where they must wait for the rains to penetrate to them before they can emerge. It is very probable that a number of these must succumb if the rains are long delayed.

Along the line of our investigations of the relation of humus to grub infestation, I learned at Deeral that the grubs had been so abundant that a child picked up at the rate of about 8 lbs. of grubs in a day, and still the cane showed no injury from them. The river-bottom land of that locality is exceedingly rich in humus, having been recently cleared from the scrub, and is subject to overflows.

CANE GRUB INVESTIGATION, NOVEMBER, 1917.

Co-operation.

The heavy rains at the beginning of November have started the emergence of the grey-back cane beetles. Now is the time for everyone to be in the harness, for it is only by co-operation that we shall have strength to successfully combat this terrible pest. The valuable information possessed by the growers, if collected and properly summarised, might enable us to complete our investigations several years earlier than if we were left to work out all the problems ourselves. Each one owes it to his own interest, as well as to the interest of the industry, to send in any information that he possesses along the line of the questions published on page 383 of the September Sugar Journal. We are placing considerable faith in cultural methods, and desire all possible evidence. However, there must be no let-up to the collection of both beetles and grubs for the present, or, at least, until we discover a more economical method of control. I cannot urge this collecting too strongly, for there appears to be a lack of interest among growers, now that a new Entomologist is appointed to handle the problem. Of course, it is a well-understood fact that every female beetle destroyed within two weeks after emergence destroys all her progeny; and it is really an economical procedure if we can get them at this time.

As I have indicated before, we can place little dependence upon parasites for these native pests, and other control measures must be worked out. Though collecting the beetles and grubs is expensive, the expense is not prohibitive, and we know that by this method the pests are destroyed.

Use of Fires and Light-traps.

Mr. Jarvis's experiments during 1916 certainly showed that our common cane beetles are greatly attracted to lights, and this line of experiments is worth following up, for it is a subject that lends itself to extensive application. Numerous light-traps should be rigged up, at the first appearance of the beetles. A trap can be made by simply suspending a lantern over a tub of water, with a little kerosene on the surface. The trap should be sufficiently elevated to have the light visible from every direction. The flying beetles bump against the glass and fall into the kerosene-covered water, where they are quickly killed.

Recent experiments with small fires are encouraging, and undoubtedly vast numbers of the beetles, during their flight, succumb in the fires of the canefields. Anyway, we are continuing investigation of this important matter, and advocate small fires, started just at dark and kept up for about an hour, every evening, during the flight of the

beetles. Where a large field of trash is to be burnt at this time, it would be well to conserve it by separating it into small blocks, and burn a little each evening. It may be profitable to save up rubbish of all kinds for fires at this time.

Lepidiota Frenchi at Meringa.

This grass-feeding species, recently described in detail by Mr. Jarvis, is becoming a serious pest of sugar-cane at Meringa. In one field of first ratoons, the grubs have gradually worked back from the grassy roadside, completely destroying patches of the cane, by eating off all the roots. In digging up the dying stools we found from six to ten large third-stage grubs of this species. These same grubs, in their younger stages, did considerable damage to the plant-cane last year, and now in their final stage they are cleaning up some of the ratoons entirely. The owner of this field is treating the infested area, at our suggestion, with carbon bisulphide, in the hope of destroying these centres of infestation, which are evidently spreading to the surrounding healthy cane. The grubs, if left alone, would feed for several months yet, and emerge as beetles next year, since they have a two-year life cycle. Large grubs ploughed up at this season, in grass-land, are very apt to belong to this species, for all grubs of the common grey-back cockchafer changed to beetles, far below the reach of the plough, several months ago.

Experimental Plots.

There is an excellent crop of cane on the half-acre plot, treated with arsenic last season, by Mr. Jarvis. Unfortunately, the experiment is not conclusive, because the owner treated the surrounding cane with carbon bisulphide, without leaving the necessary check-plots. However, though the grubs were evidently not very bad in this locality last season, a few untreated rows left at the far end of the field became somewhat infested, so that a part of the cane fell over. Walking through the field, it is evident that the part treated with arsenic is just as vigorous as that treated with carbon bisulphide, and certainly the cost of the arsenic is considerably less.

Our 10-acre block at Meringa has all of the weedy-trash ploughed in, and a part of it is covered with a heavy growth of Mauritius bean. Since we were unable to get labour to put this land in shape for October planting, we are now planning to leave the part covered with bean and work the balance through the flight of the beetles, getting all of the fifteen plots ready for March planting.

Mr. Warner's co-operation with our Department at Greenhills is going to be a mutual benefit. We shall have about a dozen plots, of an acre or more each, demonstrating principally cultural methods and the effects of poisons, fertilisers, &c.

Muscardine Fungus.

*"Experiments started in August, 1917, with the green Muscardine fungus have shown that *Lepidiota frenchi* is victimised by this vegetable parasite.

"Second-stage grubs of the above beetle were placed in cages containing infected soil of various degrees of moisture, with the result that those kept in very damp earth died in from nineteen to forty-nine days, while the percentage attacked by the fungus in drier soil was smaller and extended over a longer period. Judging by the results of another experiment with *frenchi* grubs, it seems probable that high soil temperatures do not favour the development of the fungus, since 75 per cent. of the grubs confined in cages kept at about 70 degrees Fah. succumbed within a month, whereas those subjected to higher soil temperatures remained unaffected. We propose carrying out further experiments along these lines in order to determine the action of this fungus on newly-hatched first-stage grubs of our grey-back beetle. In this connection it may be mentioned that a bacterial disease of white-grubs in America is engaging the attention of entomologists, and possibly if introduced into Queensland might prove beneficial. Grubs attacked by this organism, which is a species of *Micrococcus*, are characterised by a blackening of the affected parts.

"Excessive wet apparently favours its development, so that our climate here during the wet season should afford suitable conditions for infection in the field, since at that time of year (January to March) grubs of *Albohirta* are doing the most damage.

"The *Bacterium* in question is able to exist for over a year under artificial conditions, and has been successfully reproduced in healthy grubs by making an incision in the skin and placing them in infected soil.

"Research work dealing with the economy of digger-wasps and other parasites is well in hand.

"The life-cycle of *Campsomeris radula*, Fab., a Scoliid wasp that preys on several kinds of cane beetles, is being successfully traced from eggs laid by this parasite at our Insectary.

"Certain species of Dexiidae, the maggots of which subsist on larvae of cockchafers, are also receiving attention, and it is hoped that further study in this direction may result in discoveries of economic value.

"Our general collection of insects has been added to as opportunity offered. Several interesting species of Dexiidae, Sarcophagidae, and other Diptera, hitherto uncollected, have been obtained from scrub land.

"As the hot weather advances, numerous fresh species of all kinds of insect life make their appearance, some of which are intimately associated with various pests of sugar-cane."

* The following notes in parentheses are by Mr. Edmund Jarvis.

CANE GRUB INVESTIGATION, DECEMBER, 1917.

The primary emergence of grey-back beetles took place earlier than usual this season, about the end of October, and specimens placed in the Insectary on 9th November deposited eggs from which grubs hatched out during the first week in December.

Another emergence of this beetle occurred about 3rd December, and owing to the prolonged showery weather egg-laden female specimens are still much in evidence (14th December).

Unless we have a considerable emergence later on, this year's flight will be far below the average. Though emergence has been spread over a period longer than usual, comparatively few beetles have been on the trees at any one time.

Emergence of Lepidiota Frenchi and Rothei.

In the region immediately around Meringa, both *frenchi* and *rothei* are much more in evidence than the regular cane beetle, *L. albohirta*. These two smaller species began to emerge about the 1st of December, and (14th December) they are still abundant on the feeding trees and low shrubs, fences, grass, &c., where they are mating. These beetles emerge earlier in the evening than the grey-backs, and they are easier to collect because they mate on lower objects, and can easily be picked off by hand. Often half a dozen pairs are clustered near together, so that they can all be taken in one hand.

Although the usual biennial occurrence of *frenchi* does not take place until next year, small local emergences are generally noticed each season. At present the grubs of *frenchi* are nearly full-grown, and doing great damage in places to both ratoon and young plant cane in the region about Gordonvale. This damage results in a peculiar spotted appearance of the field, for here and there, a chain or so in extent, the cane is yellow and often dead, while the surrounding cane is dark-green and thrifty. In one field of plant cane at Meringa, fully one-third of the crop is damaged in this way. The land had not been in cane for some time, and was covered with a heavy growth of burr and grass. The soil was thoroughly worked previous to planting cane; and though many small grubs were noticed when ploughing last May, no attention was given to destroying them. These grubs were evidently the younger stages of *frenchi*, which now, in their third stage, are able to do such serious damage to the roots.

"By giving attention to the advice tendered by this Office in the monthly report for last May ('Australian Sugar Journal,' IX., p. 221), growers will probably be relieved of considerable future damage from these pests.

"On 5th November several specimens of *Anomala australasiae,* a small dark-green Rutelid beetle, were confined in cages at the Insectary, and when examined a week later a number of eggs were found that hatched on the 22nd of the same month. We intend working out the life-history of this insect, and of other species affecting cane not hitherto recorded.

Parasitism.

"With reference to investigations now in progress regarding certain indigenous parasites of root-eating cane beetles, it may be mentioned that male wasps of *Campsomeris radula* are now emerging from pupae derived from eggs laid by this species on grubs of *Lepidiota frenchi* at our Insectary.

"It is interesting to note that the male sex of *C. radula* resembles in general appearance that of the better known digger-wasp, *Diclis formosus,* with which, apparently, it has often been confused by entomologists.

"The latter species was described by Tryon in 1902 in an able and instructive treatise entitled 'A Parasite of Sugar Cane Beetle Grubs' ('Queensland Agricultural Journal,' X., No. 2).

"So remarkable, indeed, is the similarity in form and colouration of the adult males of *formosus* and *radula,* that specific distinctions are confined principally to the presence of a few additional yellow markings on the latter species that are barely visible to the naked eye."

Light Traps.

It is our desire, in present experiments with light-traps, to so simplify them that they may come into common use in canegrowing regions.

A very successful type is simply a large pan, about a yard square, with sides about 4 inches high: the light being furnished by an ordinary acetylene lamp. A sheet of glass, 9 inches by 2 feet, attached to the stem of the lamp with a string, is found to give excellent results in heading off the beetles which circle about the flame, landing them in the tray of kerosene-coated water.

It is found best to have the pan placed on the ground, for if elevated the circling beetles often land beneath it, and in many cases never find their way into the trap.

It is interesting to learn that, though the light appears to have little attraction for the grey-backs or the *frenchi* beetles after they have reached their feeding trees, *L. rothei* continues to enter the trap throughout the night. This latter species, though usually rather uncommon, was very abundant last season at Meringa, breeding in an old

abandoned field of volunteer cane. These beetles begin dropping from the feeding trees about 9 p.m., and from that time there is a continuous hum as they come to the lamps.

From what is said above it is evident that the time to catch both the grey-backs and *frenchi* in light-traps is just at dark, in the region of infestation, before the beetles reach the feeding trees. Few results are obtained by exposing the lights for more than an hour. The value of this treatment is, however, in that the female beetles are destroyed before they can lay their eggs.

CANE GRUB INVESTIGATION, JANUARY, 1918.

The flight of the grey-back beetles, though long drawn out, has been comparatively small this year in the region about Meringa Station. A few beetles are still emerging (14th January), and are to be found on the feeding trees, nearly two and a-half months after the first emergence in November. We are already finding second-stage grubs of this species in the field, resulting from these earlier emergencies.

Destruction of Feeding Trees.

As pointed out in the publications from this Office, the grey-back beetles show a decided preference for feeding upon the foliage of the Moreton Bay Ash. Since these trees are commonly distributed through the forest and often in the vicinity of grub-infested canefields, it would appear to be a profitable procedure to have them all cut out within a circumference of about a mile of such fields. Moreover, these trees, also, appear to be the favourite food plant of both *Lepidiota frenchi* and *L. rothei*. In the region immediately around Meringa, all of these beetles appear to travel about half a mile back into the forest, though, no doubt, they would travel double that distance if feeding trees were scarce. There is also the possibility that beetles forced thus far from their breeding ground to feed would not be likely to return to the canefield to lay their eggs, but would probably place them at the roots of native grasses in the forest, as they did before sugar-cane was introduced.

Trap Trees.

It might be well to keep a few trap trees about the buildings on each farm, so that the beetles could be shaken off each morning for the fowls. We have found the weeping fig work well for this purpose, for it is usually covered with the beetles every morning. The fowls feed very greedily upon the fresh beetles with no ill effects, though they do not seem to care so much for them when dried and ground up into a meal. Of course, the natural instinct is to break up the insects themselves. The cases reported of poisoning fowls by feeding them collected beetles

were evidently the result of letting the insects stand too long before they were used: hence, decay had set in and ptomaine poison developed. Beetles to be used for food of birds, and so forth, should be quickly dried, and in this form they might be an important article of diet for both fowls and insectivorous animals in public gardens. We have had a call for this kind of food during the last two years from zoological gardens.

Lepidiota Frenchi and Rothei.

Both these beetles are still much in evidence; the mating pairs hanging on the low bushes every evening, indicating that they are still emerging. After mating they feed for several days before they are ready to deposit their eggs.

In the fields (mentioned in the last report) infested with *frenchi* grubs, conditions have improved since the continuous heavy rains; the cane is greener and in some cases throwing out fresh roots. Extensive diggings show that the number of grubs is materially less and that many of them have been killed in the soil, for we often find them decayed, or, if near the surface, dried up. Of course, many are carried away by ants soon after they die. Since these fields have been literally swarming with the parasitic wasps for a month or more, we naturally conclude that they have been responsible for much of this mortality among the grubs.

Experiments with poisons in this same field proved very encouraging. Arsenate of soda mixed with megass and applied in a furrow along the sides of infested stools apparently killed all the grubs, for none were to be found in the treated section three weeks after application, though they continued abundant in the remainder of the row, an average of three being found under each stool.

Experiments with repellents, on the other hand, have given but negative results. Creosote sprayed on megass and placed in furrows alongside the stools failed to retard the grubs, though the odour was very strong in the soil after three weeks. Furthermore, any roots that came in contact with the creosote fumes were killed, and the plants showed a decided yellowing.

Breeding of Parasites.

"Breeding experiments with Scoliid parasites have been attended with marked success, and we are working out the life-history and metamorphosis of our two most useful species of digger-wasps, *Dielis formosus* and *Campsomeris radula*.

"A specimen of the latter insect that was captured in a canefield at Meringa last September lived for seventy-five days in confinement, during which period it laid twenty-five eggs upon third-stage grubs of *Lepidiota frenchi*.

"A single egg is laid on each grub, and hatches after an interval of about three days, when the tiny larva at once buries its head in the body of the paralyzed grub and proceeds to imbibe its juices.

"So rapidly does it develop at this stage that nine days later those destined to produce female wasps have become plump white maggots nearly an inch in length and have ceased feeding.

"Larvae of male wasps, although much smaller than those of the opposite sex, take just as long to mature. The shortest periods recorded by us, however, are seven days for the male, eight for the female, while nine days appears to be the average time for both sexes.

"Having withdrawn its head from the shrunken, distorted body of its victim, the maggot, after resting a few hours, spins an oval, parchment-like cocoon of tough brown silk, in which it gradually changes to a pupa, and finally into the perfect wasp, which escapes by cutting out a circular trapdoor at one end of the cocoon.

"The average time passed in the pupal stage is thirty-six days for the male and thirty-nine for female wasps.

"We have found that *C. radula* will deposit eggs upon second-stage grubs of the grey-back beetle, but apparently will not oviposit on third-stage grubs of *Dasygnathus australis* or even paralyze them.

"Data obtained at Meringa would lead us to suppose that this digger-wasp plays an important part in the control of *L. frenchi*.

"Individual females bred from cocoons at the Insectary laid two eggs per day. A single wasp of the above species was confined with six large grubs of *frenchi* in a cage containing seventy-two cubic inches of soil, and when examined twenty-four hours later two grubs had eggs on them, two were paralyzed, and the remainder killed.

"On the preceding day, however, the same wasp paralyzed twelve grubs, laying an egg upon one; she left only three uninjured of the original fifteen placed into the cage.

"Upon several occasions during early morning after rain we have observed great numbers of male wasps of *C. radula* and *D. formosus* flying energetically over the surface of land supporting young cane plants injured in places by larvae of *frenchi*. Few or no females were noticed on the wing at such times, but upon digging beneath affected stools several were unearthed together with grubs they had paralyzed.

"We may therefore conclude that, although not much in evidence above ground, the females, nevertheless, are usually well represented in the field.

"Such conclusion is amply borne out by our laboratory tests, since out of eighteen wasps of this species obtained from eggs laid by a female caught at Meringa on 26th September, 1917, nine proved to be males and the same number females, and all of these parasites emerged practically together.

"The male wasps have a habit of congregating in numbers at sundown, particularly during wet weather, and pass the night resting side by side on dead twigs, so that on certain spots one can easily collect them by handfulls."

CANE GRUB INVESTIGATION, FEBRUARY, 1918.

The majority of the grey-back beetles are now in their third stage, the stage in which they do their greatest damage to the cane roots. We found them abundantly, following the plough, both at Greenhills and Meringa. The first specimens of this stage, for this season, were collected 25th January.

Field Experiments.

The cane at Meringa, which was badly infested with *frenchi* grubs early in the season, continues to improve. Since this field is near by, we have been able to keep close observation upon the activities of the grubs, and their effect upon the growth of the cane.

During the past month some small animal—presumably a bandicoot —has dug small holes near the roots of the infested stools. Investigation shows that these holes are confined to the diseased areas, for there is no digging at the roots of the healthy canes. Furthermore, it is now almost impossible to find *frenchi* grubs under the stools where this animal has worked.

We made attempts to catch the animal with various rat-traps, baited with grubs, without success. In every instance the bait was removed from the trap without springing it.

Our 10-acre plots at Meringa are now all ploughed for the second time, in preparation for early planting. The second crop of Mauritius beans on part of this was very heavy, and went under well (25th January), so there will be plenty of humus in this area. Arsenic was applied to the vegetation on several of these plots, previous to the first ploughing, in September, and it was interesting, in following the plough this second time, to observe that there was a noticeable decrease of the grubs on the poisoned areas.

Distribution of Grubs at Green Hills.

The relation of feeding trees to distribution of grubs is well illustrated on a large estate like Greenhills. The centre of the estate suffers little, if at all, from infestation, while the fields bordering the forest or scrub are often almost a total loss. These observations are further borne out in following the plough in various parts of the estate. Very few grubs are turned up in the central fields, while they become exceedingly numerous on the edges of the plantation.

Insect Enemies of Cane Grubs.

"With further reference to the question of digger-wasp parasites—alluded to last month—it will be of interest to mention a few facts respecting the economy of *Dielis formosus*, which, although a well-known species, has not hitherto been bred artificially from the egg, or, indeed, closely studied during the earlier stages of its life.

"The female of this handsome digger-wasp, which measures about an inch in length, is mostly black, but ornamented on the abdomen or hind body with three conspicuous broad bands of bright orange colour.

"A specimen captured in a canefield last December lived fifty days in confinement at our Insectary, during which period it deposited no less than sixty-five eggs on grubs of the cane-beetle, *Lepidiota frenchi*. It may, however, have laid a number of eggs before being caught by us.

"Its mode of ovipositing is similar to that adopted by the digger-wasp, *Campsomeris radula*. The white, slightly curved egg is about an eighth of an inch in length, elongate-cylindrical, one of its rounded ends being glued to the under surface of the third abdominal segment of the grub near the legs, in such manner as to project at right angles from the body.

"After an interval of three days the young maggot ruptures the free or head end of the egg, and, remaining inside the attached shell or chorion, bends downwards until able to reach the skin of the paralyzed host, through which the head is then inserted preparatory to sucking its internal juices.

"The average period occupied by the larval stage of *D. formosus* during midsummer is less than eight days (7·75); and about five weeks are passed in the cocoon before the wasp emerges.

"The percentage of male and female specimens derived from the sixty-five eggs already mentioned was about equal; and although maggots producing the latter sex are much the larger, they develop more rapidly, and therefore mature as quickly as those of the male wasps.

"About 8 per cent. of grubs used in this experiment died prematurely, owing possibly to having been stung too severely, or perhaps sustained minor injuries when collected in the field. In such cases the parasites, of course, were unable to mature.

"Fully 20 per cent. of the eggs were destroyed by a species of mite, that very often occurs as a predaceous enemy on the bodies of soil-frequenting white grubs. In a few cases we found that an obscure disease (not yet determined) had destroyed the egg; while in some instances it had been rubbed off by the legs of the insufficiently paralyzed grub.

"In view of the fact that the entire life-cycle of this digger-wasp is completed in less than two months, and that within a week after

emerging from the cocoon the female continues its useful work, it appears highly probable that at least four, if not more, generations may occur annually. We assume such activity to be possible on account of the insect in question being parasitic upon five species of scarabaeid cane grubs, two of which frequent the soil for periods of from five to six months, while the others, including *Lepidiota frenchi*, pass at least a year in the larval stage. It follows, therefore, that this parasite need never be at a loss for a suitable host on which to oviposit.

"Adverse climatic conditions, such as excessive wet or low temperatures, would, however, doubtless operate at times as natural checks to its increase.

"Whilst dealing with this subject we may mention, as an interesting fact, that our breeding experiments this month have demonstrated that unfertilised females of the digger-wasp, *Campsomeris radula*, will commence oviposition four days subsequent to emergence from the cocoon, and that such unfertilised ova hatch in a normal manner and produce wasps of both sexes.

Additional Cane Beetles.

"About the beginning of January, specimens of a beetle, together with various grubs obtained from canefields in the Gin Gin district, were sent to this Office by Mr. H. T. Easterby for identification. The beetles, which happened to be new to our collection, proved to be a cockchafer closely related to root-eating scarabæidæ affecting cane, while the grubs included three kinds, the largest form being a species of *Lepidiota* not occurring in the Cairns district, and the remainder representing the genera *Isodon* and *Haplonycha*.

A New Cane Pest.

"A species of bag-moth (Family Psychidae), not hitherto recorded as being injurious to cane, is sometimes noticed in plantations around Gordonvale, where it occasions minor damage to the leaf-blade resembling that due to grasshopper injury.

"The caterpillar of this species constructs as a protection a tough elongate bag of silk, covering it at first with minute woody fragments, and finally, when about an inch and a-half long, adding a number of slender sticks of varying length, which being attached at one end project on all sides from the surface at acute angles, near the mouth-end of the bag. Specimens of these curious case-moths are being bred at the Insectary in order that the species may be identified."

CANE GRUB INVESTIGATION, MARCH, 1918.

The hurricane which passed through the Cairns district on the evening of 10th March upset things generally at Meringa. Most

important with regard to our experiments was the upsetting of the Insectary, with its numerous pots and cages of parasites. Practically all of the cane of the district has been flattened out, though little appears to be uprooted.

Grub-devastation Appeared very Early.

Hardly had we sent away our last monthly report when the devastating effects of the grubs began to appear by leaps and bounds. As usual, Greenhills Estate was among the first to suffer. Large areas turned brown within a week, the leaves drying up as if a fire had been through the field. Both plant and ratoon cane appears to suffer equally if located within the infested area.

As we pointed out in last report, the worst infestation is in fields lying near the timber bordering this estate; this fact is all the more evident now that the cane of the diseased areas has changed colour. It would be a tremendous undertaking to remove all this timber, but it would probably pay to go through and kill all the feeding trees of the beetles for at least half a mile back. This could be done rather reasonably and effectively with arsenic. Of course, these remarks would apply equally to any field suffering under similar conditions.

It is a curious fact that infested fields remain infested year after year, though the beetles have a one-year life cycle. Evidently they go back to oviposit in the same fields in which they emerged, simply because these fields are most convenient to their feeding trees. They could hardly be credited with a memory of their natal spot after their feeding period of about two weeks. The fact, too, that grubs disappear, in many instances, from localities after the adjoining timber is removed would seem conclusive evidence.

Introduction of New Parasites.

The tremendous importance of the problem has never appeared greater than now, as we see hundreds of acres of beautiful cane going down to destruction before the grubs; this, too, after all the money has been spent upon it to get it to a size where it would require no further work. It certainly behoves us to leave no stone unturned for the control of such a pest.

In a region like Hawaii, the natural impulse is to seek the assistance of parasites, under similar conditions, because parasites have been demonstrated to be the most effective means of control. The Planters' Association of Hawaii have spent many thousands of dollars in the search for, and introduction of, these friendly insects; but this work has been worth millions to them. It has spelled the difference between absolute failure and success. The story of the trials and hardships of their

entomologists in the search for parasites in tropical countries reads like a romance; but they have been crowned with success in almost every instance.

An island fauna, however, is very different from that of a continent, and it is very difficult to duplicate those results under our conditions. Though we have several parasites on the grubs, their work is largely neutralized by secondary parasites.

However, there is a chance that if we brought in new parasites from other canegrowing countries they might serve as an effective control, and escape the attention of these secondary enemies. It is certainly an experiment worth trying, and we are making investigation of the matter.

Insect Enemies of Cane Grubs.

"Investigations with regard to the life-history and habits of our digger-wasp parasites continue to furnish data of scientific interest; and throughout the month of February adult specimens of *Dielis formosus* and *Campsomeris radula* have been emerging from pupæ derived from eggs laid in the Insectary during December and January last. New experiments, just started (March), will deal more fully with the question of partheno genesis, and also include preliminary studies in hyperparasitism. As previously pointed out by this Office ('Australian Sugar Journal,' Vol. VI., p. 583), a large species of bee-fly (Bombylidæ) is hyperparasitic on the larvæ of our digger-wasps, and apparently destroys a large percentage of these useful parasites. Little or nothing is yet known about the life-cycle and habits of this fly, or with regard to the economy of a Rhipiphorid beetle that we have found on several occasions infesting the cocoons of Scolia wasps. Experiments, too, have been initiated with a view to determining the best method of breeding the above-mentioned useful parasites on an extensive scale for possible distribution at some future date.

"In our last report it was stated that *Campsomeris radula* would commence oviposition four days subsequent to emergence, but in the solitary case then mentioned the wasp had been kept and fed for four days in a cage without a grub. Recent data, however, have demonstrated that unfertilised females of both *radula* and *formosus* will actually deposit eggs upon third-stage grubs of our grey-back beetle within a period of from twelve to fifteen hours after leaving the cocoon.

"Such action, indeed, appears usual in the case of confined specimens, and will probably prove to be a normal procedure in the field. In this connection it may be mentioned that owing to a mistake in the manuscript of our last report the word 'wasp' was inserted in place of larvæ; the remark in question should therefore read 'and that such unfertilised ova hatch in a normal manner and produce larvæ of both sexes.'

"It is amusing to witness the tactics adopted by females of *Dielis* and *Campsomeris* whilst overpowering their hosts. The wasp warily approaches the powerful jaws of its intended victim by clinging to its body and crawling with erratic movements until encountering the legs of the alarmed grub, which, evidently aware of the impending danger, keeps squirming and pawing the air, threatening its enemy at the same time with widely opened mandibles.

"A few seconds are passed in this preliminary fencing, and then the wasp, making a sudden dive forward, seizes with caliper-shaped jaws one of the mandibles of the grub, and without loss of time drives its paralyzing sting deeply into the throat of the unfortunate creature. The effect is almost instantaneous, the rigidly convulsive body becoming limp and unable to offer further resistance, as the parasite now withdrawing its sting plunges it deliberately several times into the mouth of its victim between the maxillæ, in order, presumably, to paralyse the mandibles.

"Each detail of this little tragedy in insect life can be plainly witnessed with the aid of a small magnifying glass, the grub and wasp being confined for convenience under a tumbler upon a piece of glass or on the soil.

"Sometimes, however, the tables are turned, and the venturesome parasite is seized and fatally crushed in the sharp jaws of its adversary, in which case it appears that the victorious grub does not rest until it has cut the wasp into little pieces.

"Under normal conditions the parasite, of course, burrows several inches into the ground before reaching a suitable host, but in one of our series of experiments it was seen that a digger-wasp when allowed to paralyze a grub lying on the surface was able to undermine and bury the body out of sight in less than twenty minutes. When examined next day we found the grub had been transported through the soil to a distance of 10 inches in a vertical direction, and was lying on its back with an egg glued to the ventral surface of its body."

* CANE GRUB INVESTIGATION, APRIL, 1918.

"Investigations regarding the influence of cultural methods on the cane-grub problem look promising on the whole, although at present it is rather early to make definite statements in this connection. Such operations, however, as scarifying or ploughing deeply enough to destroy egg-chambers of the beetle and to occasion mechanical injuries to the young grubs or expose them to great solar heat and to the attacks of birds and other enemies, cannot fail to be beneficial. We are inclined

* Written from an outline prepared by Dr. Illingworth when leaving for the hospital. The few obvious mistakes are corrected in the May report.

to favour an adoption, whenever practicable, of the following cultural measures:—

(1) Cultivation of the cane during summer weather followed immediately by ploughing such areas.

(2) Late planting and persistent cultivation during the period of oviposition, and a few weeks subsequent to the disappearance of the beetles.

(3) Ploughing or fallowing land in December.

(4) Having the ground densely covered with Mauritius beans during the flight of the beetles.

"In support of the above-mentioned procedures it may be stated that certain areas under cane at Greenhills and elsewhere which were planted in October appear flourishing at present, while adjoining land planted earlier is already badly grub-eaten.

Predaceous Enemies.

"Since reporting last month, a little data have been obtained respecting the habits of bandicoots. In the intestines of a specimen recently dissected at the Laboratory, the skins of several cane-grubs (*L. albohirta*) were found, together with a wire-worm and many chitinous fragments of coleopterous and other insects. Although this animal is credited with being omnivorous, no vegetable remains were apparent, and, judging by the structure of the mouth and its forty-eight sharp teeth, it certainly seems improbable that bandicoots, as some assert, damage cane stools by gnawing the roots and young stalks.

"The small animal alluded to in previous reports as preying on grubs of *L. frenchi* is probably a species of *Phascologale*, it having been described to us as being about the size of a small rat, but with head and mouth resembling those of a bandicoot. We hope to trap and cage some specimens of this little marsupial with a view to observing its habits and dietary.

Parasitism.

"Since reporting last month, information received from the Queensland Museum renders it necessary to state that the scientific name of our common digger-wasp hitherto known to Australian entomologists as *Diclis formosa* has recently been changed by R. E. Turner, of the British Museum, to *Campsomeris tasmaniensis*, Sauss. It appears that the true *formosa*, which occurs at Kuranda and elsewhere, and is not unlike *C. tasmaniensis* in form and general colouration, does not range south of Cairns. We have not met with this species at Gordonvale. In the absence of literature relating to the question, we have naturally followed the lead of other scientists in supposing our familiar digger-wasp to be identical with *Scolia* (*Diclis*) *formosa* of Guérin.

"During the past month attention has been given to the rearing of parasites, in order to obtain scientific data with regard to their life-history and economy and to determine the best method of breeding extensively and handling them in large numbers.

"This branch of research work has been very successful, and in the event of parasitic insects being introduced into Queensland from other countries in the near future to cope with our cane grubs we are now in a position to make the best use of such material.

"The following brief account of the mode of wasp propagation practised at Meringa may be of interest to growers:—

"Digger parasites were confined separately in metal cages holding about 15 cubic inches of soil, the grubs with attached eggs being removed morning and evening and placed into cells formed in moist, compacted earth that had been previously pressed into shallow wooden trays. A convenient size of tray was found to be 16 by 13 inches, which allowed room for sixty cells, and when full they were stacked up so that the bottom of each tray acted as a roof for that below, and left just enough space to allow the larvæ to spin their cocoons. At the present time (12th April) about 750 specimens of egg, larval, and pupal stages of our two principal digger-wasps may be seen at Meringa Experiment Station.

"We wish to emphasise the fact that the cane-grubs victimised by both *Campsomeris radula* and *tasmaniensis* are chiefly those of the notorious grey-back beetle. Additional hosts affected by these parasites include *Anoplognathus boisduvalli, Lepidiota frenchi, rothei,* and *caudata.*

"The hundreds of grubs victimised at the Insectary during this month (March) are third-stage *albohirta.*

Grubs under Blady Grass.

"Recent data obtained in the field at Meringa indicate that third-stage larvæ of *Lepidiota frenchi* are still feeding in virgin soil overgrown with blady grass and other cereals. Grubs collected hastily from 120 chains of plough-furrows, 4 to 6 inches deep, on clay loam land of the above nature, yielded 107 specimens of third-stage *albohirta,* 128 of the same stage *frenchi,* and a few larvæ of *L. rothei* and other scarabæids of minor importance. The grubs of *frenchi* as a whole are still feeding, but will shortly travel deeper into the ground and form pupal chambers. It is interesting to note that these grubs were derived from eggs deposited in December, 1916, and have therefore been more or less injurious during the past sixteen months."

CANE GRUB INVESTIGATION, MAY, 1918.

Attention must again be called to the value of cultural methods as a factor in the control of cane grubs, at the same time correcting

some of the statements that appeared, inadvertently, in reporting last month. As was then stated, it is still rather early to draw definite conclusions, but the splendid appearance of certain fields, both at Meringa and at Greenhills, is encouraging.

Late planting (October) appears to be of considerable importance for infested areas. If cane is regularly cultivated, the soil is actively worked during the flight and oviposition of the beetles; and from present observations this constant stirring of the soil either deters the beetles from laying their eggs or, if they are laid, breaks up the egg-chambers, which are only a few inches below the surface, and prevents the hatching of the young grubs. At any rate, cane planted in October this season is in very good condition in both of the above regions, even though the fields are situated right in the midst of the infested areas, with grub-destroyed cane immediately adjoining.

By cutting these fields late, say next November or December, it may be possible to ratoon them so as to again avoid an attack of the beetles, for the ploughing and cultivation will coincide with their period of oviposition. We are led to this conclusion from observations at Greenhills, where certain fields, which were cut during last December, situated right in the midst of the infested area, have been successfully ratooned with little apparent injury from the grubs.

We had experiments planned for planting areas at Greenhills both in November and December this last season, but a rush of cutting and other work made it impossible to get in these experimental plots. Now, however, since the October planting looks so well we are doubly anxious to see the results of experiments in later planting on soils which will permit working during the rainy season. We shall be very grateful for information from growers who have had any experience with late planting as a means of grub-control.

Though our experiments in summer fallowing were not as complete a success as we could have wished in either of the districts noted above, due to the rapid development of certain grasses upon the ploughed ground, there was certainly a very decided decrease in the number of grubs turned up by the ploughs in these plots, as compared with areas that had not been fallowed. Undoubtedly, if the infested fields could be well worked and kept clean during December, or through the period of oviposition of the beetles, very few eggs would be laid in them, and most of the resulting grubs would be destroyed by subsequent ploughing, preparatory to early planting. Right along this line we recently had an excellent letter from a grower, who claims that after suffering from the ravages of the grubs for twenty-five years he has at last succeeded in raising a clean crop by having his ground well worked by December, preparatory to early planting. He states that he does not try to ratoon on this infested land, for ratooning multiplies the

pest, and that all standover cane in the district should be destroyed. We certainly would emphasise the ploughing out of all standover cane, for it acts as a breeding ground for all sorts of cane pests.

The fact that allied beetles in America will not deposit their eggs in fields covered with clover led us to experiment with Mauritius beans as a cover crop here. We have not, however, found that this cover offers a complete protection, for upon ploughing the beans under during January a good many grubs turned up. The abundant humus-forming material supplied by the green crop will, however, undoubtedly supply these grubs, so that they will not do serious harm to the cane which has been recently planted on the land. A possible explanation for the ovipositing of the beetles in these plots is that there was a rather abundant scattering of Natal grass present, and this may have attracted the insects.

Lepidiota frenchi in Virgin Soil.

It is interesting to note the habit of this species in favouring uncultivated areas for ovipositing. One can dig almost anywhere in blady-grass at this season and find the grubs. Those of the present year are now in the second stage, and rather small, while last year's grubs are in the third or final stage, and are forming resting cells in which they pupate, preparatory to emergence as beetles next December. The third-stage grubs have practically finished their feeding now, but those of the second stage will continue for another year, so it is unsafe to use grass land immediately for cane if the small grubs are found very abundant when ploughing.

Notes on Lepidiota rothei.

"In a recent report (January) mention was made of the occurrence at Meringa of the small cockchafer *Lepidiota rothei*, Blackburn, in considerable numbers during December and part of January. Although of minor importance as a cane pest, it was thought desirable at the time to breed *rothei* from the egg, in order to determine the duration of its life cycle. This insect emerges about the same time as *frenchi*, from which, however, it differs in being decidedly smaller and of darker colouration. The following brief allusion to the earlier stages of its life cycle may be of interest:—

"The eggs are laid from seven to twelve days after copulation, the numbers obtained from individual females confined in cages varying from four to twelve. Like those of *frenchi*, which they resemble in general appearance, these eggs, although placed close together, are not massed in a single large chamber, but deposited separately, each egg being isolated in a tiny cavity. An interval of from nine to eleven days elapses between the acts of oviposition and emergence of the young grubs, while the first larval stage occupies a period of about ten weeks. This, however, may vary considerably, as in some instances grubs

remained four months or longer in the first stage; and in one case, for example, we found first, second, and third-stage larvæ derived from eggs hatched together, and living under precisely similar conditions in respect to temperature, moisture, and food supply. The interval from second to third instars is about six weeks, and third-stage larvæ were obtained from our breeding cages by 28th April.

Notes on Lepidiota albohirta.

"Investigations conducted at Meringa on volcanic land suffering from severe grub attack revealed the fact that 10 per cent. of the grubs after having eaten every root were actively devouring the last few inches of stalk still attached to the old sets, the remnant of cane that had been previously bitten off level with the ground. These pieces of stalk were hollowed out and reduced to shell-like fragments, even the hard outside rind being eaten, which would seem to indicate that instead of travelling in search of fresh succulent cane roots the grubs are content to continue feeding on such vegetable tissue as may be readily available even though less palatable.

"The remaining 90 per cent. of larvæ unearthed on this occasion had formed cells in the hard soil preparatory to pupating, 70 per cent. of these being found at depths varying from 11 to 18 inches."

CANE GRUB INVESTIGATION, JUNE, 1918.

During the month I made a general survey of the Northern sugar-growing districts, extending as far south as Innisfail. The trip was a very interesting and profitable one, for it not only gave us a line upon the distribution of our principal pests of sugar-cane and the discovery of a valuable parasite, but, most important of all, is the acquaintance with the men who are the leaders of the industry in these districts.

Babinda District.

This whole section suffered rather severely in the March cyclone, so that it is rather difficult to say from a casual observation which fields are grub-infested and which are down only because of the wind. The grubs have mostly gone down, preparatory to pupation; but if present in the field we were always able to locate them in their pupation cells. To do this it was necessary to dig pits at least 3 feet deep—the maximum depth at which we have found the grubs, though the average depth for pupation is only about 2 feet.

Though there is evidence that the grubs of the common grey-backed beetle extend along the line from Gordonvale to Babinda, certainly the worst infestation is in the region about Fishery Creek. As in other locations, the grubs here bother the cane only on the higher ground, away from the river. The newly-cleared scrub on this ground is only

free from attack for about two years. One fortunate thing, however—a large percentage of the grubs are attacked by the Muscardine fungous disease—fully 30 per cent. in one field examined.

In the region about Cucania and Harvey's Creek a closely-related grub, *Lepidiota caudata*, is in evidence, especially in the grass land. In one pit, a cubic yard in size, I unearthed five different species of grubs—the common grey-back, *L. caudata*, *L. frenchi*, and two smaller species—all cane pests; thus clearly showing that these pests inhabit the wild land, and are ready to destroy sugar-cane if planted there.

It must be remembered that most of the land along the line after we pass Gordonvale was originally scrub, so these beetles, which are natives of the forest country, have evidently followed the advance of cane up the valley. As a factor leading to this conclusion, I may mention the farm of Pollard's at Babinda, which was cleared out of the scrub thirty-five years ago, and was free from grubs until two years ago. The grey-backs have devastated two of his fields this season.

The cane planted on newly-cleared scrub land at Babinda is apparently free from grubs, though this immunity is not apt to last long unless steps are taken to combat them.

The Mossman District.

I was interested to learn that though the grubs were once a serious pest in this section they are now little in evidence. The growers attribute this to the fact that they use sulphate of ammonia extensively as a fertiliser. There is probably some foundation for the supposition; in fact, I collected some evidence along this line last year. Part of an infested field at Gordonvale had been treated with sulphate of ammonia, with a result that was remarkable at cutting time—the treated cane stood erect and vigorous, while the untreated was all uprooted, lying about on the ground. (See Monthly Report for August, 1917.)

We have not been able to demonstrate yet whether the sulphate of ammonia has any direct action upon the insects, but we know that its action so stimulates the plant that it rapidly sends out new roots, and if these are produced faster than the grubs destroy them naturally the cane is able to hold its footing. Whatever its relation to the grubs, we would strongly advocate the use of a nitrogenous fertiliser upon most of our soils. Since nitrate of soda is a foreign product and very difficult to procure, we can get best results at present from the use of sulphate of ammonia. This latter substance really has a higher efficiency of nitrogen, though best results are obtained upon soils which are limed.

Serious inquiry at Mossman developed no other factor which could account for the disappearance of the grubs. It is interesting to note that, on the two farms where I found the ravages of the grubs, filter-press had been applied in those particular fields, thus leading to what is per-

haps an erroneous conclusion—that this substance is attractive to the beetles. In each case the cane had grown rather rank before the cyclone, and probably went down more easily for that reason. I have no doubt that grubs were also in the untreated parts of the fields, though for lack of time I was unable to demonstrate this.

From the pits that were dug I got both grey-backs and *frenchi,* the latter species much in the minority, since it usually favours wild grassland.

Parasites of the Cane Borer Beetle.

One of the most important observations of my trip was the discovery that the cane borer beetle parasites (*Ceromasia sphenophori*) are well established at Mossman. It will be remembered that Mr. F. Muir, the entomologist of the Hawaiian sugar-planters, brought these flies to the district in 1910, where he bred them on borers in large cages, preparatory to the long trip to Hawaii. I do not recall whether any of the flies were liberated deliberately at Mossman;* but in the breeding of parasites specimens escape from time to time as the doors of the cages are opened. At any rate, the flies are now thoroughly established there, and are doing most excellent work. I was unable to find any of the borers that had escaped the search of these persistent parasites, except where the canes were so buried up in trash that the flies could not get at them.

This find is most fortunate for the canegrowing sections of the North, for we now know that the flies can live and thrive in Queensland, and that they are able to hold the borer beetles in check. The unsuccessful attempt of the Colonial Sugar Refining Company to establish these parasites at Goondi in 1914 led us, naturally, to conclude that they could not live here, presumably because they were preyed upon by many enemies, as we found to be the case in Fiji.

The borer beetle is becoming increasingly abundant in the canegrowing sections of North Queensland, due largely to the lack of care in the selection of clean seed. In one instance I found a farmer deliberately using this cane for seed, because it was so badly attacked by the borers that it was worthless for milling. It is easy to surmise the result of such a practice.

With the parasites well established in a near-by district it will be a simple matter to introduce them into other centres of infestation, using care only to transfer them at a favourable season.

Innisfail District.

It was here, in the section known as Daraji, that the C.S.R. tried to establish the parasites of the cane-borer beetle, so I took the first opportunity to visit the farm where the flies were liberated in 1914. The borers were rather difficult to find—a fact which might indicate

* I have since learned that these flies became established in the field in 1910.—J.F.I.

that something was destroying them; but a most careful search revealed none of the evidences of the flies.

On this same farm, which belongs to Mr. R. Davis, was a most striking evidence of the value of late planting for grub-infested soils. A large field, which had been planted early, was a total failure, with most of the cane uprooted and rotting upon the ground, while alongside were two fields—October and November planting—which were in perfect condition. The October plants had about 4 feet of cane, and those of November about 2 feet. I was pleased to learn from Mr. Smith, Cane Inspector of the Goondi Mill, a man very keen in his observations upon the cultivation of sugar-cane, that he fully concurred with me in advising late planting for infested soils, even though the ratoons are not always successful. He states, however, that the second ratoons are usually up to standard, providing they escape the grubs.

The grubs have been particularly severe this season in the region about the Mourilyan Mill—many of the fields being a total loss. Digging pits in both cane and grassland disclosed only the grey-backs as the pest of this district.

The standing scrub was so badly whipped by the cyclone that it will offer very unsatisfactory feeding for the beetles this season, and especially if fire is run through it later on to destroy the fallen timber. There is a possibility that this factor will be a very important one in the control of the grubs next season. I should certainly advise firing the scrub whenever it is practical to do so.

Parasites of Cane Grubs.

Rather careful observations failed to reveal the presence of these wasps either at Mossman or on the Johnstone River, which is rather interesting, since they are so much in evidence in the Mulgrave district. The Muscardine fungus, too, must be rather rare in these districts, for I heard of only one instance where it was found attacking grubs, south of Innisfail. There is a possibility that we might assist materially in grub destruction by introducing these friendly agents in localities where they are not already found. In these new localities the parasites would possibly escape their natural enemies for a time, and, if so, would do a vast amount of good.

Anthony James Cumming, Government Printer, Brisbane.

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