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BULLETIN No. 19.

Notes on Queensland Cane Insects and their Control.

THIRD SERIES

BY
EDMUND JARVIS,
Entomologist.

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FOREWORD.

Bureau of Sugar Experiment Stations,
Brisbane, 5th January, 1926.

BULLETIN No. 19 (Third Series) comprises further notes on Queensland Pests of Cane, by the Entomologist at Meringa, Mr. Edmund Jarvis, and will be of great service to cane-growers generally who make a point of studying same.

H. T. EASTERBY, Director.

Notes on Queensland Cane Insects and their Control.

By EDMUND JARVIS, Entomologist.

INTRODUCTION.

THE data included in the present Bulletin have appeared hitherto in the form of Monthly Reports,* which, being scattered through the pages of our "Agricultural Journal" and other periodicals, are not easily available for reference until brought together and suitably indexed.

The present publication—which is supplementary to Bulletins Nos. 17 and 18 of this Office—covers a period of fifteen months, from October 1923 to December 1924.

Since most of the data given applies to the Cairns district, it may be well to mention that this extreme northern area of cane land is situated within 20 deg. of the equator, and has an average rainfall of fully 92 in., while the average mean temperature may be taken as about 76 deg. Fahr.

Most of this country, which is flat and almost encircled by mountain ranges, is usually termed forest land, and supports for the most part stunted trees representing such genera as *Eucalyptus, Acacia, Tristania, Melaleuca, Ficus, Timonius,* &c., the undergrowth consisting of coarse grasses interspersed with various shrubs and herbaceous plants.

On the so-called scrub lands, however, which mostly border the ranges, the vegetation is of a distinctly tropical character, both the floral and insect faunas of such regions differing greatly from those of the forest country.

These scrub lands are composed very largely of exceedingly fertile sandy or clay loams, rich in humus; some of the low-lying river flats, indeed, having produced when first cleared as much as eighty tons, or even more, of sugar-cane per acre, followed by from ten to thirteen ratoon crops.

October 1923.

SUMMARY OF PARADICHLOR. EXPERIMENTS AT MERINGA.

The experiment plots at Meringa consisted of a strip of land 605 ft. long, embracing eight rows of first ratoons of D. 1135, and ten untreated rows. Injections of paradichlor. were put in on 25th January, with the "Jarvis Injector" (designed for injecting dry material) on both sides of cane rows, from 12 to 18 in. apart, 6 in. deep, and 4 in. from stools.

* *See* Bulletins Nos. 7, 8, 10, 15, 17, 18, Bureau of Sugar Experiment Stations, Division of Entomology.

PLATE I.

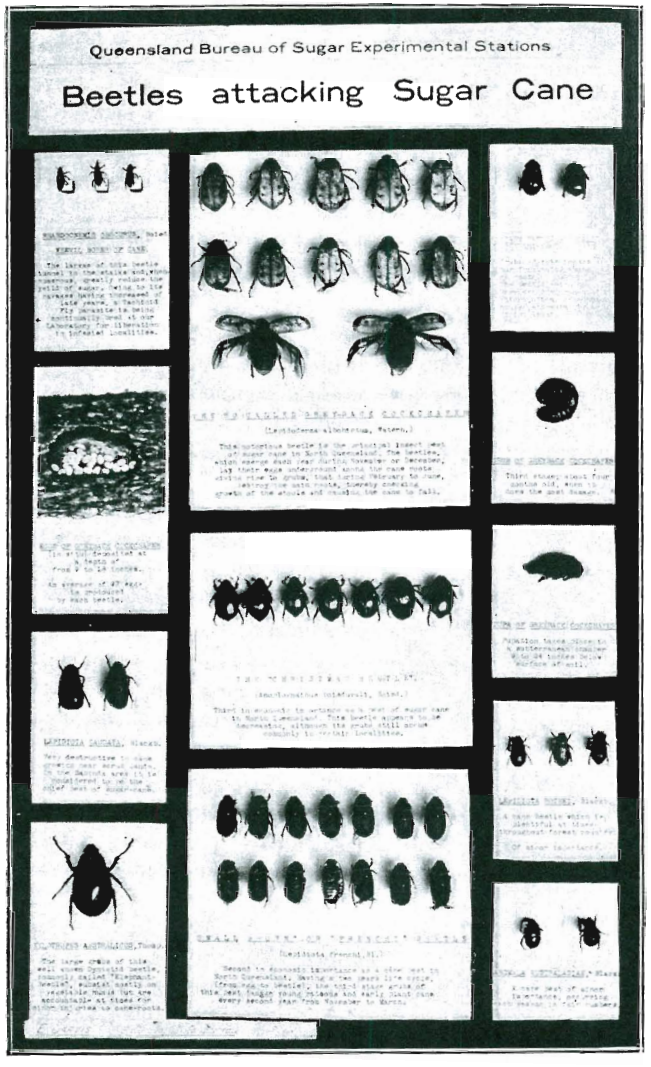


Photo., E.J. and A.N.B.

Show-case, containing Scarabæid Beetles, &c., affecting Sugar-cane.

Owing to the land having been cultivated to an average depth of only 6 in., the crystals of paradichlor. were in many cases embedded in unbroken subsoil.

A fortnight later the odour of the fumigant was noticeable 2 in. below injections, and had penetrated upwards to the surface, impregnating a strip of land about 20 in. wide situated directly under the lines of stools. Such fumigation of the soil had been accomplished by an evaporation of only one scruple of paradichlor. (one-sixth of the 4-oz. injection), still leaving sufficient in the soil (5 scruples) to maintain such fumigation for ten weeks longer if desired. Three months after application the cane was 7 to 8 ft. high, and upon looking down from a height of about 12 ft., one could at once notice the green edges of the treated areas sharply bounded by the yellowing borders of grub-infested check-plots.

At this time not a single yellow patch could be seen in the treated areas, the cane in which continued to be uniformly dark-green and healthy. When examined three weeks later (17th May) this contrast between green and yellowing grub-smitten cane had become very marked indeed, and upon counting the stools in six treated and the same number of check rows it was found that out of 1,800 treated stools 69 appeared to be grub-affected, while in the six untreated rows 1,364 out of 1,800 stools were decidedly grub-smitten.

The sickly stools occurring in treated rows were surrounded by, or growing alongside, green healthy stools, thus indicating that yellowing of the former was in many cases not due to failure of the fumigant, but probably to defective treatment or non-application, owing to some stools having been accidentally missed. This was clearly exemplified by a row of 300 stools that had been injected by one man, which presented an unbroken line of green foliage, without a single grubby stool, showing that this row had been carefully and uniformly injected throughout the entire length. Running parallel to it, and only 4 ft. 6 in. away, the edge of an adjoining check-plot formed an almost continuous row of stunted grub-eaten cane.

The unmistakable contrast between these two rows was amply sufficient in itself to prove the value of paradichlor. as a fumigant for cane-grubs.

Successful in Spite of Disadvantages.—I may state that these plots were situated on a ridge of high land composed of friable red volcanic soil; that the cane on the area selected for treatment had not ratooned well, owing to grub injury during the previous season accompanied by dry weather; and, moreover, gaps of several feet occurred in some of the rows before we injected these plots, while weakly or stunted ratoons were also noticed in other rows.

The cane was cut about the middle of September, 7½ months after injection with paradichlor., during which period it received less than half our average amount of rain. In spite of prolonged drought, however, poor cultural conditions, and other drawbacks already mentioned, the rows of treated stools continued to the last to be greener, more upright, and considerably higher than those alongside on the control areas.

I may mention here that the fumigant in question was first obtained from Germany by Mr. J. C. Brünnich, who afterwards handed the sample procured to the Director of the Sugar Bureau. This was sent to the Gordonvale Laboratory to be tested by me in connection with cane-grub control.

Ratooning of Treated Rows.—In conclusion, it may be stated that, about a month after harvesting the cane on our Meringa plots, one of my assistants, Mr. H. Knust, noticed that the stools that had been treated with paradichlor. about ten months previously were ratooning in a uniform manner, whereas in the lines of untreated cane scarcely any ratoons had appeared, while the few chancing to be present here and there were noticeably small and weakly; showing that the roots of these control stools had been more or less grub-eaten.

Entomological Exhibit at Ingham.

The Sugar Bureau was represented by this Office for the first time at the Annual Show of the Herbert River Farmers' League, held at Ingham on 21st and 22nd September, by an entomological exhibit, which included some of our best diagrams and show-cases, lately executed by the writer for our museum at Meringa Laboratory. This economic display was committed to the care of Mr. Dormer, and owing to its unique character naturally attracted considerable notice, and was evidently much appreciated by growers in this district.

Breeding and Liberation of Tachinid Flies.

This work is progressing favourably, and at the present time one of our breeding-cages contains a large number of canes harbouring pupæ of this parasite, from which flies are expected to emerge in considerable numbers during the next two weeks. On the 19th ultimo, Mr. G. Bates (assistant to Entomologist) was sent to South Johnstone to liberate sixty parasites on plantations affected by the Beetle-Borer (*Rhabdocnemis obscurus* Boisd.). Thirty-three of these were let go on the selection of Mr. Darveniza, and the remainder among Mr. Moule's cane at Miskin's Point.

Judging by information gathered by Mr. Bates, this cane-borer is to be met with over a very large portion of the South Johnstone district, the names of no less than sixty growers troubled with this pest having been obtained from the chief cane inspector.

This is a serious matter, and an endeavour will be made without delay to control the ravages of this destructive cane-weevil.

Cane-grubs have not done much damage this season on the Johnstone, and other insect pests affecting the cane are of minor economic importance.

Dried Grubs and Beetles as a Poultry Food.

Whilst in Sydney recently I submitted samples of dried grubs and greyback beetles to Mr. A. Le Souef, Curator of the Zoological Gardens, and we visited cages of various insectivorous birds, &c., to see if they would eat these grubs either whole or when broken into small pieces. Mr. Le Souef subsequently found that they preferred them in a softened condition, and in a letter just received from him he writes:—"The grubs that you left were very good food, and when soaked were readily taken by our insectivorous birds. We would be glad if you would quote for the food at per pound. We might be able to use about 100 lb. per annum."

I might mention that when discussing this matter with the Curator he told me there was a sure market in Sydney for such dried grubs, and we would have no difficulty in disposing of large quantities at a good price. The price per pound would be determined by the amount of time and trouble involved in the process of drying and packing the grubs. It seems to me that growers who collect them when ploughing might just as well turn them to profitable account as throw them away or let the birds eat them. Since it takes about 3½ lb. of fresh grubs to make 1 lb. of dried, a fair price for the latter commodity would be from 2s. 6d. to 3s. per lb.

October to November 1923.

Parasites of Cane-Borer Beetle.

The activity of this important branch of control work is being continued, and at the present time tachinid parasites of the weevil-borer are freely emerging at our laboratory.

Since reporting last month additional liberations of this useful parasite have been effected in the South Johnstone area, where this insect appears just now to merit special attention.

On 18th October two boxes containing fly-infested cane-sticks taken from a breeding-cage were established on selections situated near No. 2 branch of the main tramline. This work was carried out by one of my assistants, Mr. G. Bates, who at present is being trained here in this particular line of control, which includes the breeding, handling, transportal, and liberation of the well-known tachinid fly *Ceromasia sphenophori*.

Boxes of parasites set up in the fields amongst borer-infested cane are made to hold from six to eight sticks, 2 ft. 6 in. long, containing puparia of the parasite from which flies are about due to emerge. Each of these canes harbours from 10 to 20 fly pupæ, so that at least 100 flies may be expected to issue from a box containing eight sticks. *Note.*—When a breeding-cage contains from 50 to 100 parasites, a stick taken from such a cage for a field-box would harbour from 30 to 50 puparia; so that a box of eight such sticks would then produce from 300 to 400 parasites. The four legs supporting a field-box are stood in tins of water to prevent invasion from ants.

The tachinids simply escape through a few narrow slits left for that purpose when nailing up the box. After emerging naturally in this manner they fly off the box, and, finding themselves in the immediate vicinity of their host, are able to at once commence the useful work of parasitizing borer grubs.

On 31st October three additional cages were established in the Silkwood and Japoon areas; and 73 parasites were let go on three different selections in the mill area and at No. 2 branch.

Tachinids will be emerging daily at the laboratory during the next couple of months, and cane-growers desiring to obtain specimens should apply without delay to the Entomologist at Meringa. Parasites will be liberated free of cost to farmers who will agree to leave uncut from ¼ to ½ an acre of borer-infested cane for the flies to breed in.

Paradichlor. as a Deterrent.

Experiments with the above fumigant were commenced this season on the 9th November, with the object of testing its possibilities as a deterrent against oviposition of *albohirtum*. Beetles will appear on the wing directly the ground becomes moist enough for them to escape from the pupal cells. After copulation they will fly to their feeding-trees, and not start to lay eggs until about a couple of weeks later.

Paradichlor. is best applied either before or just after emergence of the beetles. If injected a week after their appearance the soil would have ample time in which to become impregnated with the odour of this fumigant before invasion of a plantation by egg-laden females. Ground so treated would possess strong deterrent properties, and beetles could not remain alive in it during the period of oviposition, so that any chancing to enter the soil would be compelled to hastily decamp. As a matter of fact, they would doubtless detect at once the odour on the surface soil and probably be repelled.

Thus in normal seasons the work of injecting could, if desired, be commenced in November, while the cane is quite small, as greybacks usually appear about the middle of that month, while the odour from paradichlor. endures in the soil for a period of about eight weeks. In

the event of such work being delayed until December or January, any late eggs, together with first and second stage grubs, would be destroyed before the cane had been materially damaged.

Experimentation last season demonstrated that ½-oz. injections of paradichlor. will effect impregnation of the soil about a fortnight after application, continuing repellent during a period of at least ten weeks. Now, we may safely assume, from data already obtained from laboratory and field experiments, that ¼-oz. injections put in about the middle of January would, by the end of that month (provided no heavy rain occurred during the interval), have killed all grubs present in the soil, thus effecting the desired control of this pest.

Similar results could, as mentioned last month, probably be obtained by evaporation of only $\frac{1}{24}$ oz., viz., one-sixth of the ¼-oz. injection. It follows, therefore, that such mortality could probably be secured from application of ⅛ or possibly $\frac{1}{10}$ oz. injections, seeing that the odour arising from these doses of paradichlor. would effect impregnation of the soil during a period of from three to six weeks.

Experiment plots will be planned this season to determine minimum quantities of this fumigant required per acre for effective treatment of cane-grubs. Last season's experiments worked out at from 1½ to 2½ cwt. per acre, but I hope to be able to reduce these amounts to 90 lb. or even less, which would bring the cost for material below that of carbon bisulphide or other fumigants.

The best time to apply paradichlor. is when soil is in a moist condition but at the same time open for such fumigation.

Experiment plots just started at Meringa and Kamma were treated with ⅛-oz. injections, which, in the event of beetles emerging before the end of November, should prove a deterrent against oviposition.

Carbon Bisulphide Kills Greybacks in Pupal Cells.

An experiment was carried out on 30th October, to determine the effect of fumigation of the soil on beetles of *Lepidoderma albohirtum* lying in cells at depths of from 10 to 18 in. below the surface.

The plot selected consisted of a piece of land 3 ft. 4 in. by 2 ft. 6 in., situated on red volcanic highland, ploughed about 5 in. deep, and directly over a line of stools that had been attacked by grubs. This was treated with ½-oz. injections of carbon bisulphide, administered on both sides of the row, 15 in. apart, 6 in. from centre of stools, and 8 in. deep.

When examined twenty-four hours after treatment the plot was found to contain six beetles of *albohirtum*, all of which were quite dead. Three of these were lying at a depth of 10 in., and the remainder at 12, 16, and 18 in. below the surface. The one killed at 18 in. was situated

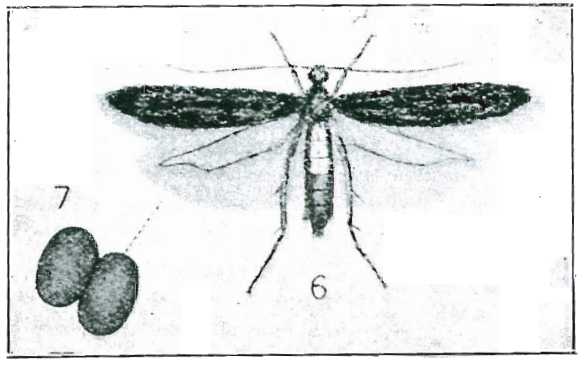
directly under a point of injection; those found at 12 and 16 in. occurred at 4 and 6 in. laterally from injections, while the three beetles at 10 in. deep were all situated about 6 in. from points of fumigation.

A single stool was then treated on four sides with ¼-oz. doses, and when examined twenty-four hours later three beetles were found under it, two of which, located at depths of 10 and 14 in., were dead; the third, lying 18 in. from the surface and directly under the stool, being alive. The top soil at time of injecting was very dry and in favourable condition for such fumigation, the ground, however, being moist below a depth of about 9 in. from the surface.

Data obtained indicate that fumes of carbon bisulphide are able to penetrate the walls of the pupal cells of this destructive beetle; and that such fumigation could, if desired, be made use of on infested areas of cane land to destroy these beetles and prevent emergence and laying of the eggs.

Tineid Moth-Borer of Sugar-cane.

Discovery of this seemingly insignificant moth-borer was made by the present writer in November 1919, when it was bred for the first time from young ratoons collected at Meringa, Kamma, and Pyramid.

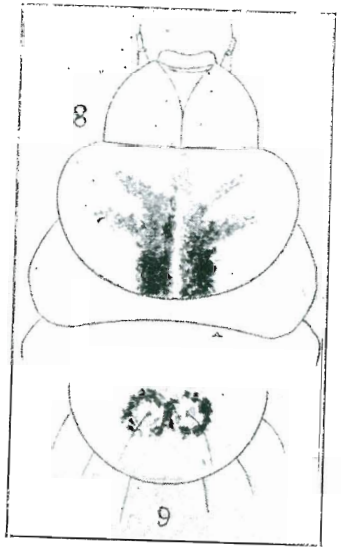


(6) *Ephysteris chersæ* Meyr. (magnified 8 times).
(7) Eggs of same, much enlarged.

A full account, accompanied by illustrations of the life-cycle of this pest, was published during 1921 in Bulletin No. 11 of our Division of Entomology. Its free occurrence this season at Banna has enabled us to breed more than 300 specimens of this moth from ratoons collected towards the end of October.

Specimens of a hymenopterous parasite of this moth were also obtained, and possibly additional insect enemies may be bred later on.

Note.—Since publication of the above report in 1923, this little moth-borer has been identified by Dr. Guy A. K. Marshall, of the British Museum, as *Ephysteris chersæa* Meyr., belonging to the family Gelechiidæ.



(8) Diagrammatic dorsal view of prothoracic segment of larva of *E. chersæa* (highly magnified).
(9) End of anal segment of same (highly magnified).

November to December 1923.

White Ants Attacking Cane.

Our earliest record with regard to cane being affected by termites was published in 1916, in Bulletin No. 3 of this Office; the two species implicated having been identified tentatively by Mr. W. W. Froggatt as *Termes meridionalis* and *Eutermes fumigatus;* neither of which, however, causes serious damage to this crop. Both these species attack the cane-sets after planting; *meridionalis* being held responsible occasionally for quite a number of misses in rows growing close to headlands. Fortunately such injuries are confined almost exclusively to the sets, although exceptional cases have occurred at Meringa where this termite during drought conditions has been discovered tunnelling in cane-sticks. Similar damage has been reported from Mossman, caused probably by a species of white-ant not found in the Cairns district.

In the so-called "Giant Termite" (*Mastotermes darwiniensis* Frogg.), however, we have a truly formidable cane-pest, which around Ayr and on the Lower Burdekin is fast becoming of decided economic importance. The nature of injury caused by this species was reported

by the present writer about nine months ago ("Queensland Agricultural Journal," vol. xix., p. 372), and since that date preliminary experiments have been carried out here along various lines of control, with view to combating its ravages. These remedial measures fall under four main headings, viz.:—(1) Fumigation of the ground, (2) Poison-baits, (3) Protection and introduction of natural enemies, (4) Use of Repellents.

With regard to the first of such control methods, the best time to commence fumigation is when young plant or ratoon cane is quite small, as at this stage of growth the termites are not likely to have invaded the stalks, but will be either entering the sets or congregating around them, prior to taking up quarters therein; so that at such times the fumes from carbon bisulphide, paradichlor., &c., would easily reach them. The latter fumigant would doubtless prove more effective than carbon bisulphide, since the fumes given off from $\frac{1}{8}$-oz. of paradichlor. would operate for at least four weeks, thus having ample time in which to impregnate the ground and penetrate into any unsealed holes in the sets, or underground portions of canes, &c.

In the event of specimens having already bored into the sets the odour from this fumigant should be able to reach them, provided the tunnels by which entry had been effected had not been closely plugged up afterwards by the termites. Injections of paradichlor. should be placed 1 ft. apart on each side of a row of cane-stools, about 6 in. from the centre of same, and at a depth which would come just above the level of the sets. This fumigant is insoluble in water, easy to handle, non-poisonous, non-inflammable, and the fumes are not in any way objectionable.

With reference to poison-baits, Mr. W. Payard, of Brandon, has found that arsenic mixed with molasses and sprinkled around the nests of this termite proved very effective. Such treatment would be worth a trial in places where infestation happens to be confined to small areas, and could be easily applied on various media; the most suitable of which, however, have yet to be determined by future experimentation. The medium used should be cheap, easily obtainable in bulk, and preferably of a manurial nature.

Experiments conducted here some months back showed that dipping sets in a solution of Paris green $\frac{1}{2}$ oz., water $2\frac{1}{2}$ pints, gave a mortality of 100 per cent. after four days. The small pieces of split cane used in this test were merely dipped in the solution and laid on top of the soil in cages containing specimens of *Mastotermes darwiniensis*, which during the hours of darkness came out of the earth, presumably, and fed on the poisoned bait. Apparently, judging by Mr. Payard's experience, this would happen also under field conditions, as, after feeding on the arsenic and molasses applied by him at Brandon, a great many of these white-ants must have died on the surface of the ground; a quantity, he tells us, "sufficient to have filled a couple of flour-sacks."

Emergence of Cockchafer Beetles.

A welcome shower of rain (0·18 in.), heralding the break-up of drought conditions, fell here on 6th December, and was at once followed by an emergence of several species of small melolonthid beetles belonging to such genera as *Heteronyx*, *Liparethus*, &c., but proved insufficient to stimulate the subterranean activity of our greyback and other related cane-beetles. Additional rain (0·98 in.), registered forty-eight hours later, enabled *Anomala australasiæ* to appear on the wing; numbers of these bronze-green beetles being observed flying around papaws and other plants.

Up to 10th December, however, no general emergence of *albohirtum* had occurred here, although at Highleigh (about 5 miles from Meringa) where the precipitation had been heavier (1·59 in.), many greybacks were noticed on their feeding-trees. Emergence commenced at Meringa on 13th December, when the rainfall during the preceding week had attained a total of 3·51 in.

Although unable at present to gauge the numerical strength of this formidable cane-insect, it may be of interest to mention that from data obtained at the beginning of December it appears that grubs are likely to do considerable damage to cane next season; but that, owing to the natural check on their increase which occurred last year, the average infestation during February to April 1924 will probably be below that experienced during normal seasons.

Control of Cane-Beetles.

Experiments are under way at present for testing the effect of various poisons on our greyback cockchafer. Results obtained by the writer during past years have shown that both lead and copper arsenates, when sprayed on the foliage of food-plants in cages, will kill all beetles chancing to eat a small portion of such poisoned leafage in from eight to ten days.

Experiments this season will test the insecticidal value of various dust sprays, &c., which in field practice are more easily applied than liquid solutions, and it is hoped may act more rapidly. Such dusting of favourite fig-trees growing near canefields, or planted for this purpose on headlands, might tend to greatly reduce the numbers of beetles attracted to them, and would also act as traps, that whilst constantly operative would require very little attention.

Another interesting phase of control which will be continued during this season is that of attempting to capture adults of *albohirtum* by means of aromas resembling those which may be presumed to normally exercise an attractive influence, either in connection with food-plants of the beetle, conditions favourable to its larval stage, or with sexual relationships.

PLATE II.

Photo., E. Jarvis.

A corner of the Entomological Museum established at Meringa Experiment Station.

December to January 1923-24.

WEIGHT OF MALE AND FEMALE GREYBACKS.

In order to determine differences in weight between the sexes of *albohirtum* during development of the ovaries, numbers of these beetles were collected at random from feeding-trees near the laboratory and carefully weighed. Ten days after emergence (21st December) it required 264 living females or 280 males to weigh 1 lb. avoirdupois. Thus during this interval each female had become about 12 grains heavier, equivalent collectively to a total weight of about 88 beetles. It appears, therefore, that a single female, prior to full development of its ovaries, weighs about 26 grains av., but when containing eggs of a size fit for extrusion weighs at least 38 grains.

Later on in the flighting season when about 60 per cent. of females had oviposited, those containing fully grown eggs could at once be separated from the above by this decided difference in weight.

As already pointed out in a previous report (February 1922), the greyback cane-beetle, although of bulky proportions, is well adapted for migration, being relatively lighter in weight than many smaller and closely related Scarabæidæ, while its buoyancy, large size, and big expanse of wing prove decided aids to such aerial transportation.

DISTRIBUTION OF TACHINID PARASITES.

Since reporting last October, nineteen additional cane-growers have been supplied with consignments of tachinid flies, sixteen of these being residents of the South Johnstone area, and the remainder of Goondi, Highleigh, and Mount Sophia. These liberations have taken the form of seventeen specially constructed breeding-boxes, containing in all 128 fly-infested cane-sticks taken from our large rearing-cages, each stick harbouring from ten to twenty or more puparia of this tachinid.

As a result of such liberations fully 1,600 flies are expected to issue from these boxes; which, as previously reported, are established in the canefields amongst stools affected by the grubs of *Rhabdocnemis obscurus* Boisd. After escaping through slits left in the covers of the boxes for this purpose, the tachinid parasites fly on to the standing cane, and finding themselves in the immediate vicinity of their host are able to at once commence the useful work of parasitizing the borer grubs. It is encouraging to be able to state that while "scouting" for tachinid flies at the farm of Mr. B. Salleris at No. 1 branch, parish of Johnstone, on 18th January, Mr. G. Bates succeeded in finding three empty puparia of *Ceromasia sphenophori* in a standing cane-stick; indicating that this parasite has been able to gain a footing, and commenced to breed naturally in that locality. Forty flies were liberated at this spot on 1st November, and a box containing seven fly-infested sticks was also established there on 14th December.

Experiments with Paradichlor.

A number of plots situated in various localities have been injected with paradichlor., in order to observe its effect on cane-grubs when applied in small doses. Some of these plots were treated a week or so after emergence of the beetles, to see whether egg-laden females would oviposit in soil contaminated with the odour of this compound. It is hoped to establish additional plots during the month of February until commencement of the wet season.

Experimentation in this connection has been entrusted to Mr. H. Knust, who obtained considerable experience in this class of work last season. Half a ton of paradichlor. has been received this month (January) at Meringa Experiment Station, the sample being of good quality and costing about £2 5s. per cwt. At this price it would cost, say, £1 18s. to treat an acre consisting of 6,000 stools with ½-oz. doses injected on each side of the rows of cane.

Poisoning Greyback Cane-Beetles.

Experiments have been conducted this season to test the insecticidal value of arsenical dust-sprays. Results obtained by the writer during past years have shown that both lead and copper arseuates in solution will kill beetles of *albohirtum* in from eight to ten days after feeding. Data derived this season from the application of dry arsenicals indicate that these poisons, when dusted thinly on the foliage of favourite food-plants, will kill these beetles in less than 2½ days after feeding. The investigation in question took the form of ten separate experiments in which 299 beetles were used, including 104 control specimens. Ten per cent. of the beetles eating leaves poisoned with lead arsenate died half a day after feeding; while 50 per cent. of those poisoned with Paris green succumbed in about twenty-four hours.

January to February 1924.

Grubs Expected to Cause considerable Damage.

Now that the flighting of cane-beetles has ceased, one hears on all sides such questions as the following:—"Will grubs be plentiful this season?" "What damage are they likely to do?" &c., &c.

As previously mentioned in a recent report, greyback cane-beetles appeared this season from December to January in considerable numbers. During the fortnight preceding oviposition 150 points of rain fell, which, being accompanied by an average temperature for those fourteen days of 79·50 deg. Fahr., including a mean maximum temperature of 89 deg. Fahr., permitted normal development of the eggs. It is important to note also that an additional 9·17 in. was registered during the period passed in the egg condition, prior to hatching of the first-stage grubs.

We may, therefore, infer from the above facts that, climatic conditions having proved very favourable to the greyback cockchafer, its grubs are likely to show up presently in great numbers. It will be remembered that last year this pest received a severe natural check, more than 50 per cent. of the beetles having perished in the ground owing to a long-continued spell of dry weather. As pointed out recently, we may, I think, expect severe damage to cane next April, although in all probability the average infestation is not likely to come up to that experienced during normal seasons, in which the rainfall in the Cairns district for the period November to February averages 49·32 in.

At the present time very few grubs of *albohirtum* have entered on the second instar, since out of 116 collected on 11th February only 6 were in the second instar. By the end of this month, however, first-stage grubs of this species should be unprocurable.

Field investigations in this connection on the above date revealed third-stage grubs of *frenchi*, feeding amongst cane-roots in fairly dry soils at depths varying from 6 to 8 in. Out of thirty-six stools examined, grubs of *frenchi* were found under fourteen and of *albohirtum* under eleven stools, while larvæ of both these cane-beetles occurred together under two of the stools. Examination of the soil beneath clumps of "star grass" and of "sugar grass" (*Sorghum halepense* Pers.) yielded an average of about eight first-stage *albohirtum* grubs feeding at depths of from 5 to 10 in.

Field Work.

Several experiment plots have been established this year in various localities, in order to accumulate further data in connection with the fumigant paradichlorobenzene, the efficiency of which was established last season at Meringa. Present experiments are designed to determine the minimum amount of paradichlor. required per acre to afford protection from this pest, and to kill its first and second stage grubs. It is hoped this may be accomplished by injections of $\frac{1}{10}$ oz. placed 12 in. apart and 4 in. deep.

Experimentation having been limited this season to the establishment of small plots consisting of from $\frac{1}{10}$ to $\frac{1}{8}$ acre, most of the work has been done with the "Jarvis Injector," invented for burying dry fumigants or other crystalline chemicals, &c.

Machine for Paradichlor.

Growers will be interested to learn that early this season (15th October) the present writer got into touch with Massey-Harris Company Limited, with view to having a machine built for treating large areas with paradichlor. The requirements of such a machine were fully described to them, and, as a result of various suggestions, the firm has endeavoured to meet the situation by making certain additions and

alterations to one of their corn-planters. A machine was accordingly sent to us early in January, which when tested in the field succeeded in dropping and burying uniform quantities of paradichlor. about 2 in. deep and 15 in. apart. This was effected by the use of four circular plates pierced with holes adapted for dropping doses of $\frac{1}{16}$, $\frac{1}{16}$, $\frac{1}{8}$, and $\frac{1}{4}$ oz. As a result of this field test, additional improvements in construction were carried out locally; after which the machine was found to work satisfactorily in well-cultivated soil. Results already obtained in this direction mark a decided step forward, since with such an appliance it will be possible for one man and a horse to fumigate from three to four acres a day, thereby reducing cost of application to a minimum.

Experiments with Calcium Cyanide.

Last August I received a letter from the Cyanamid Company of New York, drawing attention to the merits of calcium cyanide, which is being used at present for destroying rabbits, orchard pests, fleas, wireworms, &c.

A sample of this insecticide has now been obtained from Buzacott and Company Ltd., of Sydney, with which initial experiments have been commenced, with view to testing its effect on grubs of our greyback beetle, *Lepidoderma albohirtum* Waterh.

This sample is marketed as grade B, costing about 8d. per lb., being in the form of a dark-grey powder, which during decomposition by moisture of the air or soil generates hydrocyanic acid and calcium hydroxide. Although very deadly, this insecticide is not dangerous to handle if reasonable precautions be observed. The hydrocyanic acid gas is given off during a period of about twenty-four hours, thus allowing time for the fumes to penetrate some distance in light soils open for such fumigation. It is worth noting, also, that the residue left behind in the ground after complete evaporation of the hydrocyanic acid contains no poison (as is the case with a material like white arsenic), being simply ordinary slaked lime.

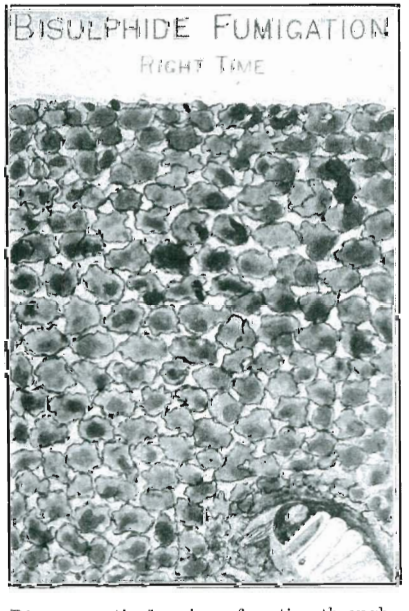
Laboratory experiments started this month (February) with caged grubs of *albohirtum* are yielding very promising results, data obtained up to the present indicating that a dose consisting of only 8 grains of calcium cyanide is sufficient to kill first-stage grubs of *albohirtum* and third-stage grubs of *frenchi* in less than twelve hours, when sprinkled about 2 in. above the level at which they are feeding, and then covered by a couple of inches of soil. The cages of earth used in this experiment were about 4 by 3½ in. in size, and left open at the top. We have yet to determine the distance that hydrocyanic gas will travel vertically and horizontally on each side of 8 to 10 grain injections, and what effect it may have on growing roots of cane.

I am of opinion that the poisonous nature of calcium cyanide will not prove a serious drawback to its use in canefields, since it would not, like Paris green or lead arsenate, &c., need to be dusted through the air, but simply buried underground. The paradichlor. machine being now built for us by Massey-Harris, for instance, should be just the right thing for putting in calcium cyanide. Being enclosed in an airtight container, fumes from this insecticide could not reach the operator, who would neither see nor smell it during its application to the soil. The granular form of calcium cyanide would probably suit our purpose better than the grade B dust, being more convenient to handle than the latter, and perhaps evaporating over a longer period. The price of the former, put up in 200-lb. drums, is 17½ cents per lb.

February to March 1924.

Wet Weather Affecting Soil Fumigants.

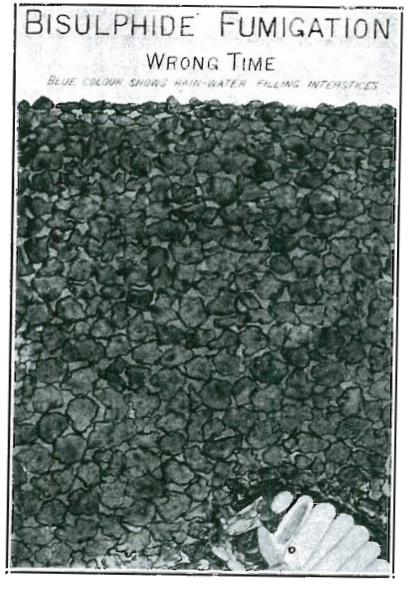
Since reporting last month the wet season has set in, and during the period 6th February to 12th March we have registered 16·28 in. of rain at Meringa. Such conditions have necessarily interfered somewhat with outside experimental work, porosity of the soil having been closed against various methods of fumigation for combating cane-grubs, by excess of moisture.



(Photo., E. Jarvis.) Diagrammatic drawing of section through soil above a cane-grub.

(A) Interstices between soil particles filled with air, open for fumigation.

An instance of this was noticed on one of our experimental plots near Cairns, the cane on which had been treated with paradichlor. on 2nd February. Rain fell on the day following application of the chemical, and on seventeen subsequent days during that month, the total fall being 7·81 in. As a result of this downpour the fumes of paradichlor. from injections of ⅛ oz. buried 4½ in. deep were unable to penetrate through the wet soil, so that when some of the cane on this plot was examined on the 28th (25 days after injection) living grubs were present under both check and treated stools. Owing to such closing of the soil, the doses when dug up appeared to have lost very little weight from evaporation. All the grubs unearthed (14 under a check and 7 under a treated stool), consisted of second-stage *albohirtum*. Should two or three weeks of dry weather supervene before the end of April, the land in question may yet become open enough for this fumigant to penetrate and kill a fair percentage of third-stage grubs before they have had time to completely destroy the cane.



(*Photo., E. Jarvis.*) (B) Interstices clogged with water, closed against fumigation.

It is worth noting that, during the time when paradichlor. ceases to operate owing to wet conditions, the quantity injected does not decrease, as this chemical is insoluble in water, but simply remains in abeyance, as it were, for the time being, until excessive moisture has drained away. Similarly, it is useless to apply carbon bisulphide to wet

ground, more especially if this be of a clay or clay-loam nature; any heavy class of soil, indeed, being often difficult to fumigate successfully unless well worked and thoroughly drained.

Experiments with Calcium Cyanide—continued.

Mention was made last month that preliminary tests with this deadly poison against caged grubs of *albohirtum* proved very encouraging. Having found it would kill grubs located just under injections, a series of experiments were made to determine how far hydrocyanic acid gas would travel laterally in the soil with fatal results. The cages used contained about 144 cubic inches of soil, the poison being placed in the centre of each cage and about 1½ in. below the surface. In the first experiment three cages were used, and a first-stage grub of *albohirtum* placed at opposite ends of each cage, 2 in. below and 2 in. to one side of the poison. One of the grubs in each cake was prevented from moving farther away from the injection by a vertical screen of wire gauze.

When examined 24 hours later, results were as follows:—

Cage A.—Dose 15 grains of calcium cyanide; both grubs dead in the position placed.

Cage B.—Dose 15 grains; grub imprisoned by wire gauze, dead; other grub had moved to one side and was dead.

Cage C.—Dose 8 grains; both grubs dead, in original position.

In another experiment (22nd February), in which 15 grains of this poison was buried 1½ to 2 in. below the surface, second-stage grubs were placed 4½ in. from the injection laterally and 2 in. below same. When examined about 20 hours later results were as follows:—

Cage D.—Both grubs dead, but had worked about half an inch nearer to the surface.

Cage E.—Both grubs dead.

Cage F.—One grub had travelled into corner of cage and was dead; the other sick, but still able to move its legs.

In a third experiment, conducted 25th February, second-stage grubs of *albohirtum* were placed 2 in. under and 4½ to 5 in. away from injections of 15 grains; and when examined 24 hours later results were as follows:—

Cage G.—Both grubs dead; one had moved an inch nearer the poison, the other was in original position.

Cage H.—Both grubs dead; had not moved from original position.

Cage J.—Both grubs dead and soft; one had moved half an inch nearer the poison.

Further experimentation and initial field-tests will be carried out this month (March), when it is hoped to study the effect of this poisonous gas on growing cane-roots, &c.

PLATE III.

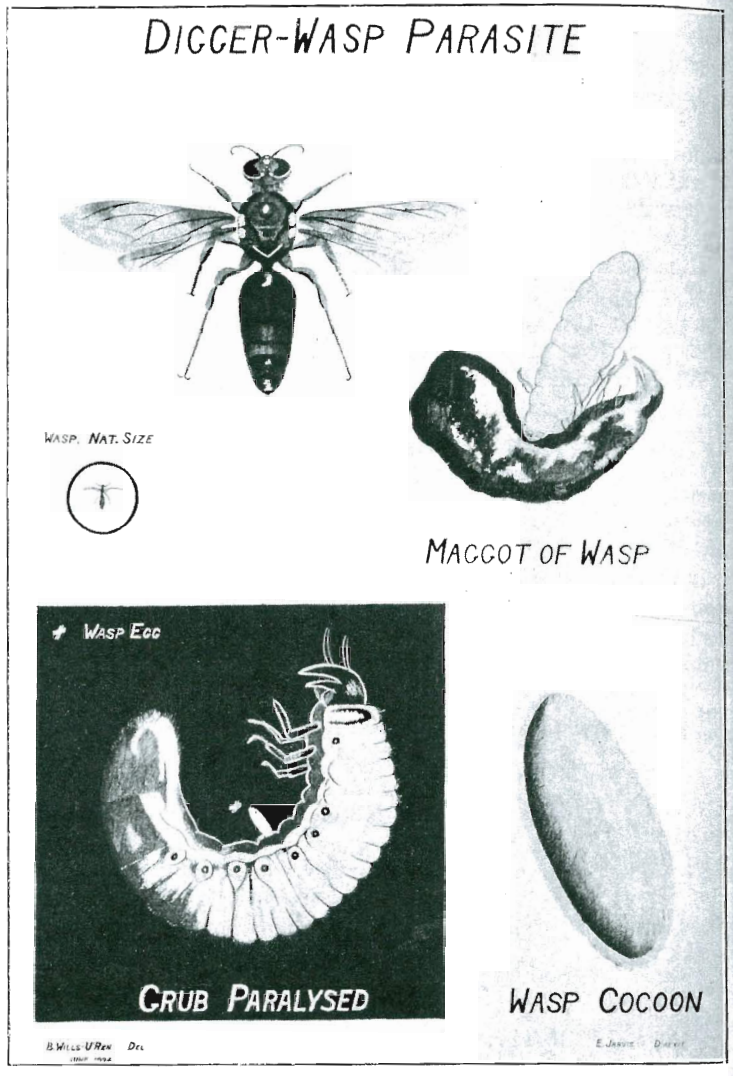


Photo. of coloured diagram (5 ft. x 3 ft. 6 in.) showing the life-cycle of the Digger-wasp *Campsomeris tasmaniensis* Sauss., drawn by B. W. U'Ren.

QUEENSLAND SCOLIID WASPS.

Referring to the question of parasitic enemies of our various scarabæid grubs, it will be of interest to mention that about nine native species of scoliid or digger-wasp parasites occur in the Cairns district; these being classed under the genera *Scolia, Campsomeris, Discolia,* and *Tiphia.* A single species of *Lepidoderma,* three of *Lepidiota,* and one of *Anoplognathus* (which include the so-called grey-back cockchafer, and "Golden" or "Christmas" beetles) are freely parasitized by wasps of *Campsomeris tasmaniensis* Sauss. and *C. radula* Fab. The two most favoured hosts, however, are *L. albohirtum* and *L. frenchi.*

Grubs nearing the end of the second instar appear to be readily victimised by these scoliids; wasps of average size often ovipositing, for instance, on small second-stage *frenchi,* and conversely, females below average size parasitizing big third-stage grubs of *albohirtum.*

Such readiness to oviposit, while naturally enhancing the economic value of these wasps in Queensland, would increase the possibilities of their usefulness in other countries into which they might at any time be introduced to combat root-eating scarabæid grubs.

Campsomeris ferruginea Fab., our largest digger-wasp, measures 1⅜ in. in length and nearly ⅜ in. across the body, which is black with four dull-reddish transverse bands on the abdomen, while the thorax, legs, and front of head are thickly clothed with stout rust-coloured hairs. This wasp probably attacks the grubs of our large species of Scarabæidæ.

C. carinifrons Turner, which is our smallest species of *Campsomeris* (about ½ in. long), is uniformly black. Its abdomen is ornamented with four bands composed of cream-coloured hairs, and the costal area of the forewings is suffused with bright yellowish brown. This parasite may prey on grubs of such genera as *Neso, Haplonycha,* &c., and possibly those of our smaller species of *Lepidiota.*

Scolia formosa Guer. is a very handsome wasp of deep orange-chrome colour, broadly barred with black on the abdomen. It is parasitic on grubs of *albohirtum,* and perhaps those of other related Scarabæidæ, but has only once been bred here from the egg. The wasp measures about 1⅛ in. in length.

S. verticalis Fabr. is a small black digger-wasp about ½ in. long, having a yellow patch on the vertex (forehead), and iridescent pinkish-brown wings.

Discolia soror Sm., a shining black wasp about the length of *Scolia formosa,* but more slender, attacks grubs frequenting sandy soils, of such genera as *Anoplognathus* and *Dasygnathus.* It is easily distinguished by the beauty of its smoky-brown wings, which flash with iridescent metallic shades of deep purple and rich ultramarine blue.

Tiphia intrudens Sm., although perhaps of little economic significance at present, deserves passing notice on account of its close relationship to *Tiphia parallela* Sm., which has proved such a useful parasite against various white grubs in other sugar-growing countries.

March to April 1924.

BREEDING DIGGER-WASP PARASITES.

The work of breeding additional specimens of our scoliid wasps of the genus *Campsomeris* for introducing into Java has been continued during the present month, capture of these useful parasites and subsequent rearing of same in the laboratory having been successfully carried out. Digger-wasps were scarce in canefields throughout February, which was a dry month, but following on a fall of 5·62 in. of rain (from 3rd to 9th March) they emerged freely, and on the 10th of that month 22 female wasps were captured without difficulty in about an hour. These were induced to oviposit regularly each day; so that early in April we were able to send a consignment of cocoons and larvæ to Prof. Leefmans at Buitenzorg.

The present season happens to be particularly favourable for this class of control work, as grubs of *Lepidiota frenchi*, which are now in the third instar and form one of the favourable hosts of *Campsomeris*, are available this year for such purpose during January and February; while those of *albohirtum* are procurable as usual later on from March to May.

Various original ways of packing these parasites were tried, with the object of reducing risk of injury during transit to a minmum.

The consignment forwarded to Java this month consisted of 65 specimens, including intra-cocoon, larval, and pre-pupal stages of digger-wasps of the genus *Campsomeris*.

NOTES ON THE ECONOMIC VALUE OF PARASITES.

Our growers have long believed that the introduction into Queensland of some parasitic enemy of the greyback cockchafer would afford a ready means of solving the cane-grub problem.

It should be remembered, however, that past experience has shown that employment of this attractive means of control has succeeded best when directed against insect pests that have obtained entrance into a country accidentally, and in which, being unchecked by their usual parasitic and other enemies, they have found themselves able to increase and multiply abnormally. It stands to reason, therefore, that the control of such species would most likely be effected, in many cases, merely by the introduction of those insect enemies which have always limited their activities in the country from which such introduction may have originated. The utilisation of parasitic insects in this way

dates back to about 1842; although, perhaps, the first notable success in recent times was achieved in 1889 by the introduction from Australia into California of a small "ladybird" beetle called *Novius cardinalis*, to control our so-called "cottony cushion scale" (*Icerya purchasi* Mask.), which having found its way into the latter country was working terrible havoc in the citrus orchards and defying all attempts at artificial control measures.

Nearly 11,000 specimens of this useful little beetle were reported as having been bred from the specimens first obtained from Australia by the Department of Agriculture, and ultimately liberated in more than 200 affected orchards in California, where they cleaned up the citrus trees so effectively that in less than twelve months this formidable scale insect was held in complete subjection.

Similar useful work was performed also by this ladybird beetle in New Zealand, and later in Portugal, where the cottony cushion scale, having entered both countries, was fast ruining the orange groves.

Taking an instance of our own work in this direction, it may be mentioned that the well-known tachinid fly parasite, which is a natural enemy of the weevil-borer of cane in New Guinea, is at present being bred in considerable numbers by our Bureau of Sugar Experiment Stations, and liberated among borer-affected cane in various sugar-growing districts of Queensland. Results derived from such liberations bid fair to prove highly satisfactory, this parasite of the borer having already been successfully established in many centres (*see* this report under separate heading below). With regard to the possibilities of useful control work being achieved by parasites introduced into Queensland in expectation of their subsequently attacking grubs of indigenous species of cane-beetles, any success in this direction would necessarily depend mainly on the degree of relationship between the two species concerned, and incidentally on other natural factors too numerous to touch on in a monthly report. Briefly, we know that many leaf-eating insects, when removed from their natural habitat, are nevertheless able to acquire new habits, and that a species, in order to persist and multiply, will often strive to adapt itself to an unfamiliar dietary. Similarly, parasitic insects, when unable to find their accustomed host, would for the same reason be compelled either to accept the most fitting substitute that chanced to offer, or face the alternative of failure to perpetuate their species. Such adaptability, however, is by no means rare among highly organised hymenopterous insects like digger-wasps, ichneumons, &c.

TENACITY OF LIFE IN CANE-GRUBS.

Laboratory experiments were carried out this month in order to determine how long a third-stage grub of *albohirtum* (greyback) could remain alive under water, under such conditions as might arise when

PLATE IV.

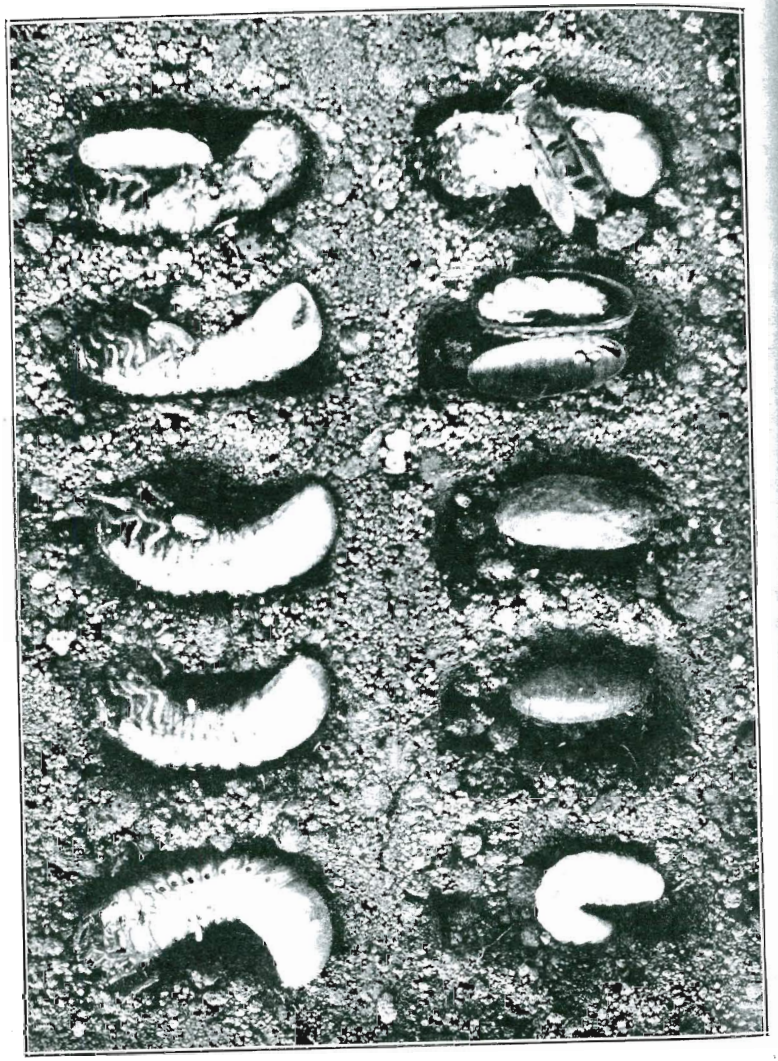


Photo., E. Jarvis and A. Burns.

Eggs, Larvæ, Cocoons, Pupa, and Imago of *Campsomeris tasmaniensis* Sauss. on paralysed Grubs of *Lepidoderma albohirtum* Waterh., in earthern cells of breeding-tray. (Nat. size.)

low-lying river flats become completely submerged at flood time. Full-sized grubs were placed singly in test-tubes containing rain water, in which, after struggling a few seconds, they sank to the bottom. About an hour later, all motion had ceased and they lay in doubled-up position with legs widely extended. Grubs taken out of the water after intervals of 5½, 26, and 32 hours' submergence ultimately recovered, while those subjected to 40 hours' immersion did not revive. In a second experiment grubs were found to recover from a submergence of 41 hours; but others, although regaining slight movement after 47 hours under water, did not live more than three days. Again, others subjected to 66 hours' immersion continued motionless for a time and then commenced to decompose. When first taken from the water all grubs felt cold and stiff, the body, however, regaining its usual softness after an hour or so in moist soil.

BREEDING TACHINID PARASITES OF BORER.

This branch of activity is being continued from month to month, and parasites are emerging at present in our rearing-cages in fair numbers. Latterly, most of these specimens have been females, some of which were liberated this month at South Johnstone, while others are being retained for breeding purposes. During the cooler months, liberations will mostly take the form of breeding-boxes containing sticks harbouring pupæ of this tachinid fly, from which the parasites will emerge and breed naturally among borer-infested cane left by the grower for this purpose. It is interesting to note that on a selection at Mirriwinni, where these flies were released about three years ago, they are now thoroughly established; and upon visiting the place in July 1923, and again this month (March 1924), plenty of fly puparia were discovered on each occasion in standing cane affected by weevil-borer.

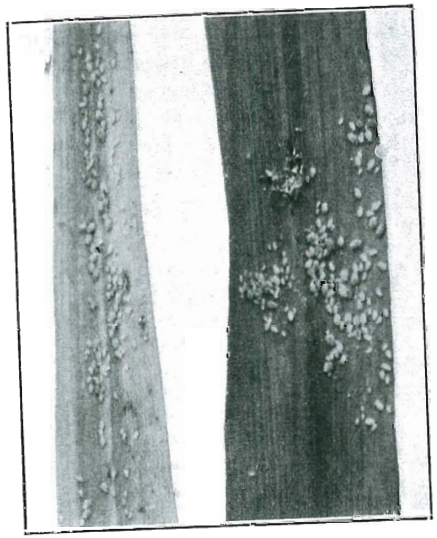
Once established in this way the parasite will continue to do its part, unless unthinkingly destroyed or severely checked by firing of the trash throughout the area in which it is breeding.

CANE-GRUB INFESTATION.

It is early yet to state definitely the percentage of grub attack likely to be experienced in the Cairns district. Up to the present the weather has favoured growth of the cane, and formation of fresh roots to replace those bitten through on grubby areas. During February and March there have been eight intervals, varying from one to eight days, on which rain has not fallen, the precipitation for these two months having totalled 27·70 in. In spite of such welcome conditions, however, indications of the presence of grubs are to be seen at present (15th April) on high volcanic canelands, being very noticeable over areas on which cane was cut after flighting of the beetles.

In some cases ratoons on such land are little more than 3 ft. high, and being already quite brown and drying up are practically worthless.

Evidence of the presence of grubs may be seen, too, on the Greenhill Estate. Grubs of *albohirtum* are now in the third stage and growing rapidly. During the next three weeks (terminating about 12th May) they will continue feeding voraciously on the roots and underground basal portions of cane-sticks. Evidence obtained last season showed that these grubs do not, as some growers suppose, travel through a canefield, or even between the rows from one line of stools to another, but are content to remain among the roots of the stool under which the eggs they were hatched from were originally deposited by the parent beetle. After devouring the main succulent roots, the third-stage grubs usually commence eating holes in the underground portion of canes, and if present in numbers the whole stick is soon bitten through, or so weakened that it is blown over and falls to the ground. By the time these grubs have finished eating the basal portion remaining in the soil, the old "set," and the remains of any cane-butts of a previous crop, it is about time for them to think of pupating. When fallen stools are hidden or partially covered by trash, cane chancing to rest in contact with the surface soil is often eaten into by grubs that have come to the top of the ground under cover of the semi-darkness. It is not unusual to find cane-sticks attacked in this manner, and nearly eaten through in well-covered portions.



Aphis sacchari Zehn. on leaves of Sugar-cane. (Nat. size.)

April to May 1924.

Aphides Attacking Sugar-Cane.

An interesting outbreak of the common plant-louse, *Aphis sacchari*, occurred in the Babinda area towards the middle of March; small patches

of varying extent being affected on several canefields bordering the Russell River. This insect was first noticed by the writer on cane-leaves close to the Mulgrave River in 1914, and has been long known as a pest of this crop in Java and elsewhere (*see* Bulletin No. 3 of this Bureau, Entomological Division).

In Queensland, however, it is kept well in check by numerous parasitic and predaceous insects, so seldom effects serious damage, unless the increase of its enemies should happen to be adversely affected by abnormal weather conditions. Being only $\frac{1}{10}$ in. in length, and of much the same colour as the foliage, they generally escape notice, although congregating often in countless numbers, comprising specimens of tiny larvæ no bigger than the point of a pin, wingless viviparous females, nymphs with rudimentary wings, and winged forms of both sexes.

Aphides are known to increase abnormally during a prolonged spell of warm dry weather. The rainfall for March and April this year has been one-third less than the usual amount for that period; while the average shade temperature during these months has been 78·49 deg. Fahr., as against that of 75·57 deg. Fahr. for March and April of 1923. Possibly these differences in rainfall and temperature may be responsible in part for the present outbreak.

Sooty Fungus on Cane Leaves.

Early in April I was advised that the leaves of some cane at Moolaba were turning black, as though attacked by a fungus, which was said also to be checking growth of the affected stools.

The trouble, as I expected, was found to be due in the first instance to the presence of *Aphis sacchari;* the blackening of the leaves, however, being caused by a fungus (*Capnodium* sp.) known commonly as "Smut," "Sooty Mould," "Fumagine," &c. This organism is not parasitic, but merely grows on the surface of a sweetish secretion scattered freely over the leaves by aphides while sucking the sap. Although of secondary importance, this fungus certainly retards plant growth by shutting out light from the cells, choking the stomata or breathing pores of the leaf, and interfering with the natural escape of watery vapour, &c. Fortunately, by the end of April—most of the aphides having by that time succumbed to the attacks of natural enemies—rain had commenced to loosen and wash this fungus and honey-dew from the foliage, allowing stunted stools a chance to recover normal activity.

Additional species of Aphidiidæ recorded by the writer in 1916 as affecting cane at Gordonvale and Meringa include a large dull-yellow globular aphis, noticed during late winter and early spring months clustered in small colonies on the basal portion of underground shoots or buds of sets planted about 4 in. deep; and a slender pale-green species

suffused with bluish grey on head and prothorax attacking the leaves; both these aphides, however, being of minor economic interest (*see* Bulletin No. 3 of this Office).

Tachinid Parasites Emerging in Large Numbers.

The last few weeks have proved particularly favourable for the propagation of *Ceromasia sphenophori*. During the period 7th April to 10th May (five weeks), the average shade temperature in our breeding-cages has been about 74·50 deg. Fahr., while only 6.44 in. of rain have fallen, the days having been mostly cloudy, with frequent light showers, cool nights, and very little wind. On 7th April ten cane-sticks stocked with 70 borer grubs were put into a breeding-cage containing about 60 parasites, and just five weeks later flies commenced to emerge freely from these infected sticks. The cane used was half-grown Badila, stood as usual in moist soil; the holes made for insertion of the borer grubs being slightly plugged with fibre from broken-up cocoons. The above-mentioned weather conditions are evidently ideal for rearing of such parasites in confinement, since the canes used are able to retain their moisture, whereas under high temperatures a certain percentage of canes that do not happen to root afresh are liable to become somewhat dry, and by shrinking slightly may affect normal development of the borer grubs. Nearly 400 parasites appeared in the cage between the dates 10th to 15th May.

One hundred of these flies were forwarded at once to Macknade, in order to help on the work of breeding *Ceromasia sphenophori*, being carried on by the Colonial Sugar Refining Company at Macknade Mill.

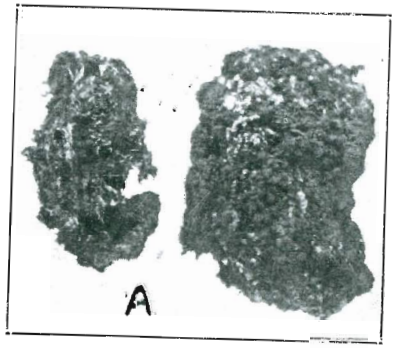
Grubs from the Herbert River.

Advantage will be taken of our visit to this district to procure samples of root-eating grubs of such cane-beetles as do not occur in our more northern plantations as cane-pests. The species said to be injuring cane on the Herbert River will probably prove to be either *Anoplognathus punctulatus* Olliff. or *A. smaragdinus* Ohaus, the so-called "green beetle" of that district, that is collected during the flighting season and sold for about 2s. 6d. per quart. Again, *Anoplognathus frenchi* may have to be reckoned with as being destructive to cane in some degree. This species, together with *A. mastersi* Macl., feeds on the foliage of plants that occur commonly on the banks of the river at Halifax and Macknade; both these beetles being very beautiful insects of a uniform metallic gold or golden-green colour.

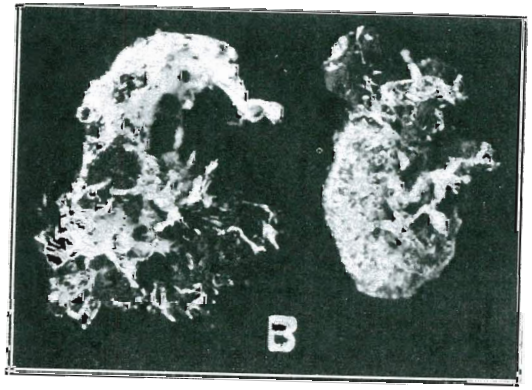
We hope to obtain sufficient living grubs of the above species to enable them to be reared through to the pupal and imago stages; and also acquire conclusive evidence as to which species, if any, attack cane-roots in the Herbert River district.

Muscardine Fungus Destroying Cane-Grubs.

As mentioned in Entomological Hints for this month (May), the green muscardine fungus (*Metarrhizium anisopliæ* Metsch. Sor.) is in evidence at present in our canefields; a small percentage of third-stage grubs of *albohirtum* doubtless falling victims to this vegetable parasite.



Lumps of earth containing grubs killed by *Metarrhizium*. Note the fungus strands binding together the soil particles.



Grubs of *albohirtum* enveloped by fungus strands of *Metarrhizium anisopliæ*.

One can now find either the mummified grubs entirely encrusted with green spore-masses, or lumps of soil about the size of a hen's egg bound together by fungus strands, which when broken open reveal the remains of a dead grub more or less intermingled with the green spores of *Metarrhizium*. This entomogenous or insect-destroying fungus has been recorded on many different hosts in other countries, including beetles, grasshoppers, froghoppers, digger-wasps, &c.

PLATE V.

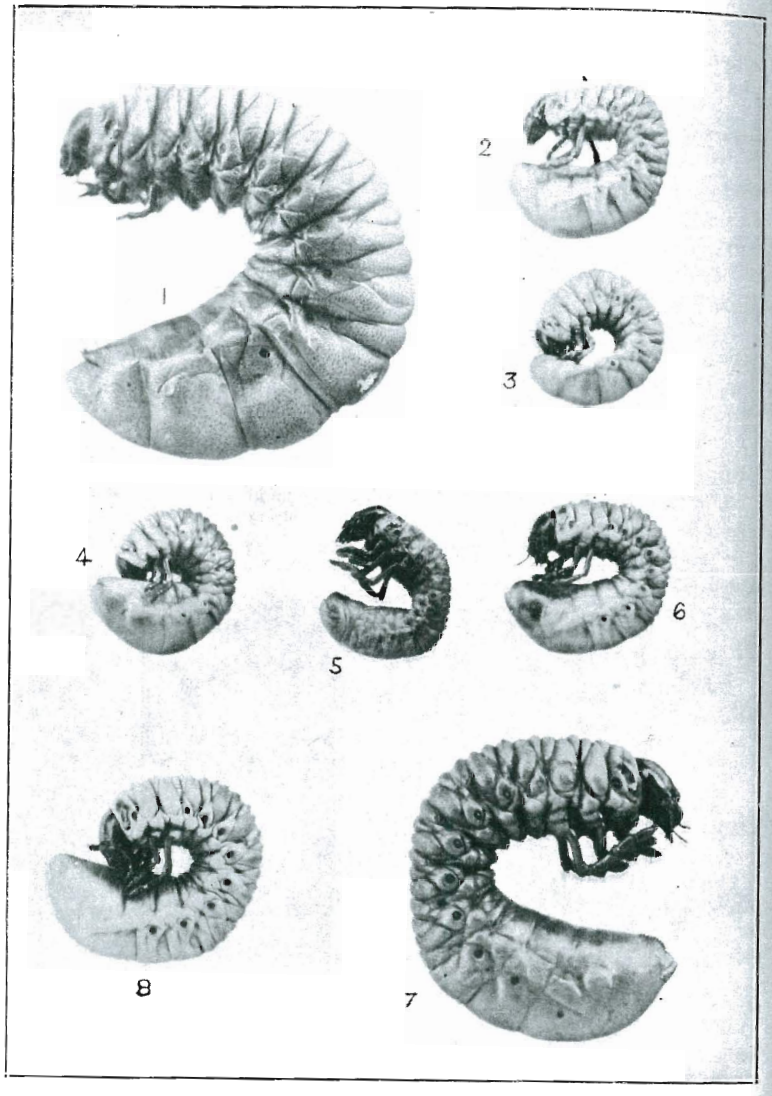


Photo., E.J. and A.N.B.

Scarabæid Grubs attacking Sugar-cane in Queensland. (Nat. size.)

(1) *Xylotrupes australicus* Thoms.
(2) *Lepidiota frenchi* Black.
(3) *Anoplognathus boisduvali* Boisd.
(4) *Dasygnathus australis-dejeani* Macl.
(5) *Lepidiota caudata* Black.
(6) *Lepidiota consobrina* Gir.
(7) *Lepidiota froggatti* Macl.
(8) *Lepidoderma albohirtum* Waterh.

In the Cairns district we have noticed it affecting the grubs of several species of Scarabæidæ attacking sugar-cane, as well as the common weevil-borer *Rhabdocnemis obscurus* Boisd., and killing larvæ and imagines of our digger-wasps, *Campsomeris tasmaniensis* Sauss. and *C. radula* Fabr. The possibilities of this fungus as a controlling factor against the cane-borer are being investigated at present, and we hope to be able later to report favourably in this connection.

May to June 1924.

Liberation of Tachinid Flies.

Mention was made in my last monthly report of a big emergence of tachinid flies at our laboratory early in May, 100 of which were sent to the Macknade Mill for distribution among borer-infested cane. These flies carried well in glass tubes measuring 9 by 1½ in., stopped with a wad of moistened cotton wool; food being provided during the journey in the shape of small wafers of freshly cut sugar-cane. They were liberated by Mr. G. Bates about 1½ miles below the mill in a block of standover Clark's Seedling.

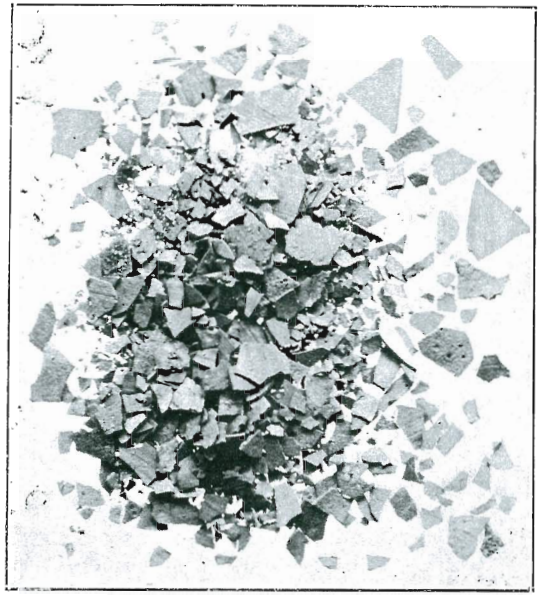
Vegetable Parasite of Tachinid Flies.

Towards the end of May the entomogenous fungus *Empusa* sp. appeared in a large breeding-cage containing about 300 specimens of *Ceromasia sphenophori*. Several dead flies were observed on the 21st instant adhering in the characteristic attitude to mosquito netting, leaves, &c., which upon removal to a damp chamber quickly developed a luxuriant growth of the conidiophores of this interesting genus. The spores or conidia, when ejected, are able, when coming into contact with healthy tachinids during favourable atmospheric conditions, to germinate and destroy them in a few hours.

Cane-Grubs of the Herbert River District.

Wishing to ascertain which species of our Scarabæidæ are destructive to cane-roots around Macknade, ploughs were followed on various selections, but, unfortunately, grubs brought to the surface in this way proved to be those of the common greyback (*Lepidoderma albohirtum* Waterhouse), the "Christmas Beetle" (*Anoplognathus boisduvali* Boisd.), *Lepidiota rothei* Blackb., and *Dasygnathus australis-dejeani* Macl.; all of which occur more or less plentifully in canefields of the Cairns district. I was hoping to come upon grubs of the so-called "Green Beetle" of the Herbert River farmers, imagines of which are often collected during the flighting season and paid for at the rate of about 2s. per quart. This species is perhaps *Anoplognathus mastersi* Macl., a lovely metallic greenish-gold beetle about ¾ in. long. It is said to feed on the leaves of *Commersonia echinata*, and on bamboo. Possibly, however, the grubs of

either *A. punctulatus* Olliff. or *smaragdinus* Ohaus, the beetles of both of which are bright green, may be injurious to cane; the latter species having indeed been found frequently eating the foliage of *Hibiscus tiliaceus* growing freely along the banks of the river. I am inclined to think *smaragdinus*, which is of a brilliant green colour, will ultimately prove to be the species in question, as *mastersi* is uniformly golden, the greenish flush not being sufficiently marked to attract attention at first sight. The term "Golden Beetle," used by Burdekin growers for one of their cockchafers, is evidently applied there to the species we call "Christmas Beetle" in the Cairns district—viz., *Anoplognathus boisduvali* Boisd.



A. N. Burns.

Calcium Cyanide (flaked form). (Nat. size.)

From data now to hand it may be gathered that *albohirtum* does most of the damage to cane on the Herbert; *boisduvali* coming second in economic importance, and then *australis-dejeani*. The occurrence of grubs of the last-mentioned species on seven different selections near Macknade is somewhat surprising, since this beetle, like other related dynastids, is known to subsist principally on vegetable débris, humus, &c. In the Cairns district it is a minor pest of cane, while *boisduvali* comes about third in importance, and *Lepidiota frenchi* Blackb. second.

Experiments with Calcium Cyanide—continued.

Following on our first experiments last February with this insecticide—accounts of which were published in previous monthly reports (*see* "Australian Sugar Journal," vol. xv., p. 708, and xvi., p. 66)—investigation of the possibilities of this form of cyanide as a controlling factor against cane-grubs has been continued at our laboratory.

It may be mentioned here that calcium cyanide, when acted upon by watery vapour in the air, generates hydrocyanic acid gas; the residue left in the soil after evaporation being ordinary slaked lime. The former is a well-known and exceedingly deadly fumigant.

Since reporting last I have received samples of the nodular and flaked forms of this insecticide, the latter of which, being cleaner to handle and taking longer to evaporate than the powder and other forms, appears the most suitable for our purpose.

During last April, thirty-six cages of moist soil, each containing a single third-stage grub of *albohirtum*, were treated with from 8 to 12 grains per cage of flaked calcium cyanide, placed about 3 in. above the grubs. When examined 24 hours later all specimens were found to be quite dead, and a strong odour of cyanide still pervaded the soil. A dose of 10 grains applied 1 ft. apart on both sides of the cane-rows works out at about 30 lb. of the insecticide per acre; and if found effective in field practice it would be cheaper than either paradichlor. or carbon bisulphide.

Preliminary tests were applied during May to determine the effect of calcium cyanide on growing cane-roots. Up to the present the outlook in this connection looks promising. Three cane-stools about 1 ft. high growing in the open were injected on each side with 20-grain doses of the flaked form, placed 6 in. from stools and 3 in. deep. This double dose (at rate of 60 lb. per acre) had no effect whatever either on the leaves or growth of these plants.

Later, in a field experiment carried out on 16th June, four young plants of Badila from 9 to 12 in. high were treated with 40-grain doses (20 grains on each side), 6 in. from plants, and sprinkled in the soil at a depth of 6 in., each dose occuping a space of about 8 sq. in. The next four plants in the same row were left as controls; while four plants adjoining this check received similar treatment as to application, but 60-grain doses per plant. When examined 48 hours later, both the growth and appearance of treated and control stools were found perfectly normal; and no odour of cyanide could be detected in soil around injections. Again, when looked at 8 days after treatment all plants in this row (both treated and control stools) had made equal growth.

Success of Paradichlor. as a Grub Fumigant.

The various experiment plots treated with paradichlor. this season have again yielded interesting data. Although grubs have not been

PLATE VI.

Photo., F. Jarvis.

North-west end of Experiment Plot injected with Paradichlor. on Mr. E. C. Earl's estate at Woree, showing contrast between the treated area and the grub-eaten stools of cane alongside to the right hand. A plan of this plot is shown at A, on Plate VII. (Photo. taken about six months after injection of the fumigant.)

very plentiful anywhere, some of these plots were laid out in grub-infested canefields. On such areas the stools on blocks treated last January with this fumigant have remained standing erect and perfectly green, in marked contrast to cane on adjoining check-plots which commenced to go yellow about two months ago, and in some cases has fallen over. Much of this grub-eaten cane would have died altogether, had not intermittent showers and cloudy weather enabled it to produce a few fresh roots and heart-leaves.

On plots of Badila, D. 1135, and Clark's Seedling free from grub attack, which were injected with varying doses of paradichlor. ($\frac{1}{16}$ to $\frac{1}{4}$ oz.), testing its action on the growth of young ratoon and plant cane, the result in all cases demonstrated that this fumigant does not in any way injure the plants, there being no difference whatever in height or colour between rows of treated and check stools.

The above results, obtained in more or less striking degree during this season and last year wherever grubs have been present, afford conclusive proof of the insecticidal value of paradichlor. as a remedy for this cane-pest.

When, as was the case last April, stools that had been injected with $\frac{1}{4}$-oz. doses could be plainly seen, three months after application of the chemical, from a distance of a quarter of a mile standing out as dark-green strips amongst the yellow grub-eaten cane, one is forced to believe the fumigant used to be the controlling agent.

June to July 1924.

SPECIAL PROGRESS REPORT.

To the Director,

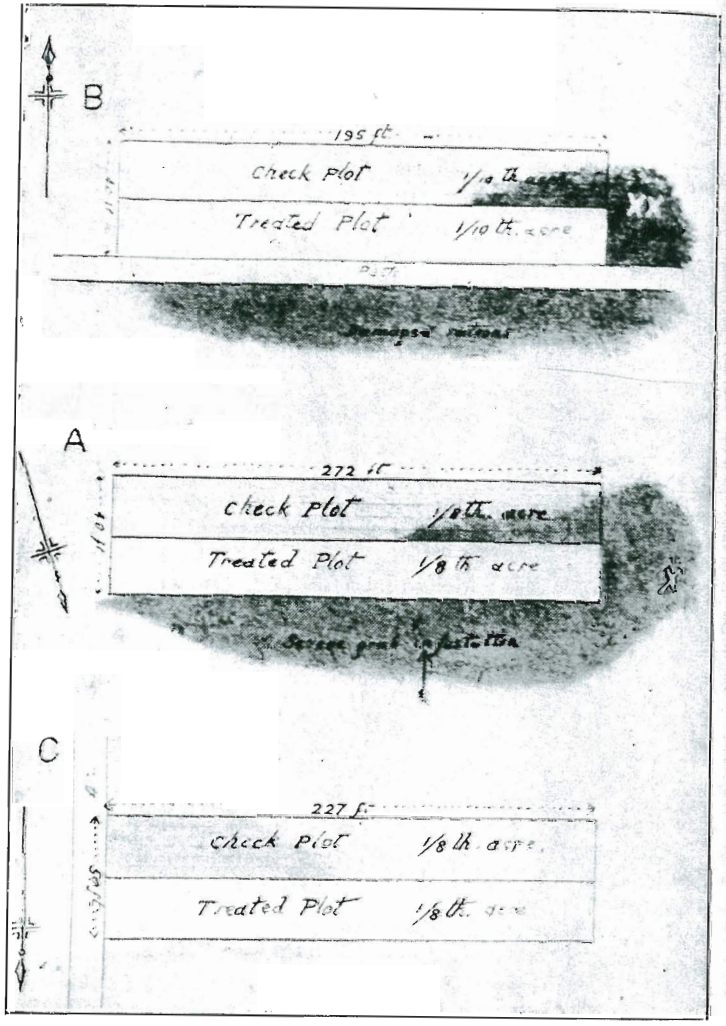
Bureau of Sugar Experiment Stations.

SIR,—I have to submit the following report dealing with control of the grub stages of our greyback cane-beetle, *Lepidoderma albohirtum* Waterhouse.

In a previous report (May to June 1923), the results of certain experiments carried out at Meringa and on the Greenhill Estate with paradichlorobenzene proved highly satisfactory (*see* "Queensland Agricultural Journal," vol. xx., p. 15; and "Australian Sugar Journal," vol. xv., p. 235); but, with view to obtaining further data in this connection, fifteen additional experiment plots were laid out during December to January last at Woree, Highleigh, Freshwater, Sawmill Pocket, Aloomba, Meringa, and Hambledon.

The cane treated embraced both plant and ratoon crops of Badila, D. 1135, and Clark's Seedling; my object being to test the action of this fumigant not only on scarabæid grubs, but also on the rooting system and ultimate growth of the stools.

PLATE VII.



Diagrammatic Sketch-plans of Experiment Plots fumigated with Paradichlor. to destroy Cane-grubs.

(A) Variety D. 1135 at Woree; (B) Badila at Freshwater; (C) Clark's Seedling at Aloomba.

Note.—Cane on treated plots is unaffected by grubs. Grub damage is indicated by dark shadowing.

Doses varying from $\frac{1}{16}$ to $\frac{1}{4}$ oz. were buried at an average depth of $4\frac{1}{2}$ in.; injections being made from 12 to 18 in. apart, and about 6 in. from centre of stools.

Conclusive Proof of the Efficiency of Paradichlor. as a Fumigant for Cane-Grubs.

The Woree Experiment Plot.—The cane on grub-infested areas commenced to turn yellow and fall over towards the end of March last; such damage, however, not being widely distributed, but occurring for the most part in large patches of varying extent.

At this time, the plot of D. 1135 treated with paradichlor. at Woree on 18th December (August planting) could be plainly noticed from a hillside more than a quarter of a mile distant standing out as a dark-green strip amongst the surrounding rapidly yellowing cane.

Naturally this contrast became more noticeable as the season advanced and additional grub-eaten stools on the check-plot collapsed and fell over.

When visited by the writer on 17th June practically all untreated stools coming within this grubby area were to be seen lying on the ground; while those on the fumigated plot (a strip 272 ft. long by 20 ft. wide) presented an unbroken dark-green wall of cane about 8 ft. 6 in. high. This standing cane was best observed from among the prostrate stools on the north-west check-plot—indicated by position of arrow on accompanying plan (page 40)—which being mostly down, and no higher than one's knees, permitted a side view of the treated strip. A splendid demonstration of the effectiveness of such fumigation occurred at the north-west end of the plot, where grubs had destroyed the cane all around this portion (as shown on accompanying plan at X); this injury coming butt-up against the treated stools, which had remained untouched and of a normal green colour, while cane on the stricken area presented the appearance shown on Plate VI.

Freshwater Experiment Plot.—This plot of Badila, consisting of $\frac{1}{10}$ acre—late July planting—was injected on 30th January; two rows of 3 chains length receiving $\frac{1}{8}$ oz. and three rows $\frac{1}{4}$ oz. of paradichlor.

The soil was inclined to be stony, and at the time of injecting was moist and in good condition for treatment, while the cane was then well out of hand. When visited on 2nd July (about five months subsequent to injecting) the treated plot was found unaffected by grubs, which, however, had severely damaged control ratoon plants on the southern side (*see* sketch plan B).

Stools on the northern check-plot were also more or less grub-eaten; while those at the eastern side, which had been badly attacked, had all gone over. At this point, where the fallen cane stopped short against

the treated strip the contrast was most remarkable, affording conclusive proof of the efficiency of paradichlor. as a grub destroyer. This plot was doubly interesting from the fact of its having shown that ½-oz. doses were sufficient to kill the grubs, there being no perceptible difference between rows treated with ½ oz. and those receiving double that amount.

Aloomba Experiment Plot.—This consisted of ⅓ acre of Clark's Seedling, which was injected 29th January, the cane at the time being about 5 ft. high. One-third of this area was given ½ oz. and the remainder ¼ oz. injections.

Although grubs did not chance to occur in sufficient numbers to kill the cane, their presence was revealed during the dry weather experienced in April and May; at which time the cane growing on check-plots adjoining each side of the treated strip was observed to turn yellow and manifest decided evidence of grub injury. Such infestation, although for the most part confined to a large patch at the eastern end (*see* sketch plan) was enough to show the contrast between treated and check stools, the former of which remained perfectly green and unaffected by grubs throughout the season, while stools forming the check areas on each side of the treated plot, although kept alive during the remainder of the season by intermittent showers, failed to regain their normal colour.

In each of the above-mentioned districts, the experiment plots alluded to yielded unmistakable evidence of a positive nature regarding the insecticidal action of paradichlor. on root-eating cane-grubs; and, had the season been a dry one accompanied by greater infestation, all the control cane surrounding the plot at Woree, and possibly that at Freshwater, would have turned brown and died, leaving the fumigated cane standing alone amidst the general ruin.

Fumigation with Paradichlor. does not Injure the Cane.

It was instructive to note that in canefields free from grub attack the stools on treated and control plots were of uniform height, colour, and general appearance, proving that such fumigation had not in any way affected normal development of the stools. On a plot of D. 1135 at Highleigh, indeed, the grower was of opinion that, although no decided evidence of grub injury could be noticed either on the treated or check plots, cane on the former appeared to be slightly higher than that on the untreated portions. Upon comparing the length of sticks from these plots while they lay in the field after cutting, this difference in tonnage was quite appreciable. Unless growth of some of these stools outside the treated area had, in reality, been slightly checked by grubs, we have no alternative but to assume that paradichlor., like carbon bisulphide, may stimulate growth of the cane by destroying certain injurious soil bacteria.

In view of the fact that an application of the former fumigant operates throughout a period about forty times the length of that occupied beneficially after an injection of carbon bisulphide, such an assumption is not at all unreasonable.

Application and Cost of Paradichlor.

During 1922 to 1923 the price of this fumigant in its crude and refined forms has varied from about £1 18s. to £5 10s. per cwt., the latest quotation from Sydney (June 1924) being £1 19s. The cost of material for treating an acre with ½-oz. doses of paradichlor., placed 18 in. apart on each side of the cane-rows, would not exceed £2, while the same dose injected at intervals of 12 in. would cost (according to the latest quotation) £3 per acre.

With the machine proposed to be manufactured under my direction by Massey-Harris and Co. for putting paradichlor. into the soil (*see* "Australian Sugar Journal," vol. xv., p. 708, March 1924), one man and a horse could fumigate from 3 to 4 acres a day; so that the cost of such application would not exceed 10s. per acre.

Uses of Paradichlor.

In all probability paradichlor. will ultimately come into general favour as a fumigant for destroying root-eating grubs of various economic insects, and at the present time is being largely used for fighting beetles, &c., attacking stored products, larvæ of moth-borers, white-ants in houses, &c.

The following advantages of this fumigant as a controlling factor against subterranean insects are very briefly enumerated:—

(1) Its influence continues operative during a prolonged period, extending from six to eight weeks or more.

(2) It is not objectionable to handle, not poisonous, and non-inflammable.

(3) It is insoluble in water, and accordingly unaffected by wet weather.

Paradichlor.* is marketed in the form of irregular small lumps, nodules, or granules of variable size, and of a colour ranging from whitish or light yellowish grey to pale greenish yellow. It dissolves very readily in chloroform, carbon bisulphide, ether, &c.

A liquid form (ortho-dichlor.) can be obtained at a cheaper rate than the para. compound, but unfortunately the former evaporates completely in about a couple of days after application to the soil. Again, when nodules of paradichlor. are dissolved in such liquid media, which is then injected into the ground, any recrystallisation of this chemical taking place would necessarily consist only of exceedingly minute

crystals, which being separate one from another amongst the soil particles would evaporate completely in about the same time taken by ortho-dichlorobenzene.

Thus, it becomes advantageous to inject the paradichlor. form of this compound, and also to employ large nodules, fumes from which will be operative during a period of from six to eight weeks.

In the experiment plots fumigated last year with my injector, the paradichlor. used in these experiments was first passed through a sieve having a mesh of $\frac{3}{8}$ in. The insolubility of these crystals in water is of course greatly in its favour, since during wet weather evaporation practically ceases, becoming operative again as soon as excess of moisture has drained away.

When to Apply Paradichlor.

If injected during the wet season, when grubs have started to damage the crop, the chances are that, on low-lying situations or areas supporting sufficient growth of sticks to overshadow the ground between the rows, such land may remain closed against passage of the fumes until the end of the season, in which case an erroneous impression may get around to the effect that paradichlor. will not kill cane-grubs.

As a matter of fact this actually happened during the 1922 to 1923 season on a piece of land at Woree, which was injected on 19th March when grubs were in the third instar and had noticeably damaged the cane. Injection was in this case followed almost at once by a precipitation of 14 in. of rain during the next eleven days. The cane on the treated plots, being over one's head, kept the ground from drying, and when examined about three weeks later it was found that no perceptible evaporation of the paradichlor. had taken place, and most of the grubs unearthed were alive.

About a couple of months after application, however, when excess of moisture had commenced to drain away, another examination of these plots made on 31st May revealed a mortality of about 50 per cent. of grubs present; ten of these treated stools when dug up yielding collectively twenty-three living and twenty-four dead grubs (*see* "Queensland Agricultural Journal," vol. xx., p. 376, November 1923). The best time, then, to apply this fumigant is during December and January, commencing directly greybacks appear on the wing, which usually occurs some time in November. During these two months the ground is generally in fit condition for such fumigation, and, moreover, one is able at this time of year to get among cane and work the ground without risk of damaging the young crop.

In addition to the influence exercised by soil porosity, evaporation of this chemical is also affected by degrees of temperature. Our average

shade heat during December and January is about 83 deg. Fahr., which, combined with suitable soil conditions, permits of very free evaporation of the fumes of paradichlor.

During experimentation at Gordonvale in 1915 the writer observed that, in dry weather, $\frac{1}{4}$-oz. doses injected in light volcanic soil at a depth of 7 in., and subjected to an average temperature of 69 deg. Fahr., lost nearly 50 per cent. in weight during a period of fifteen days, but did not quite disappear until the end of six weeks.

Soil under cane-stools treated 5th March smelt strongly of paradichlor. on 8th May—three weeks after complete evaporation of the crystals—from which fact we may assume that a limited area of such contaminated soil, comprising, say, a strip of land 1 ft. wide, would continue to be repellent against further invasion until such odour became less decided.

On open soils, during dry summer weather, $\frac{1}{4}$-oz. injections are not likely to entirely evaporate in less than from five to six weeks, but seven to eight weeks may be taken as the period of continuous evaporation for most soils during average climatic conditions.

When freely exposed to air and daylight, however, on my office table, it was found that $\frac{1}{4}$ oz. of the crushed crystals took about fifteen days to completely evaporate, under an average shade temperature of 84 deg. Fahr.

How to Inject Paradichlor.

This is accomplished either with a hand injector or a machine, the latter mode being, of course, desirable when treating large areas. All of our experiment plots, excepting one at Kamma, have been fumigated with a hand injector designed by the writer to meet the need for treating small areas of land with insecticides of a dry or crystalline nature. This appliance, which is simple and inexpensive, would be very serviceable in orchards for fumigating fruit-trees to destroy root-boring beetles, wire worms, &c. The machine experimented with in this connection (alluded to under the heading "Cost of Paradichlor." in this report) does not actually inject, but buries uniform doses of the chemical at regular intervals along the rows of cane.

The fumes given off from these crystals are harmless to human beings and domestic animals, and, being about five times heavier than air, work downwards among the interstices between soil particles. Injection, therefore, should be made about an inch above the level at which grubs are found to be working. Although the vapour as a whole naturally tends to sink in this way, a proportion of the fumes are also drawn towards the surface during the process of evaporation of moisture by the sun. Growers should remember that paradichlor. when acted

PLATE VIII.

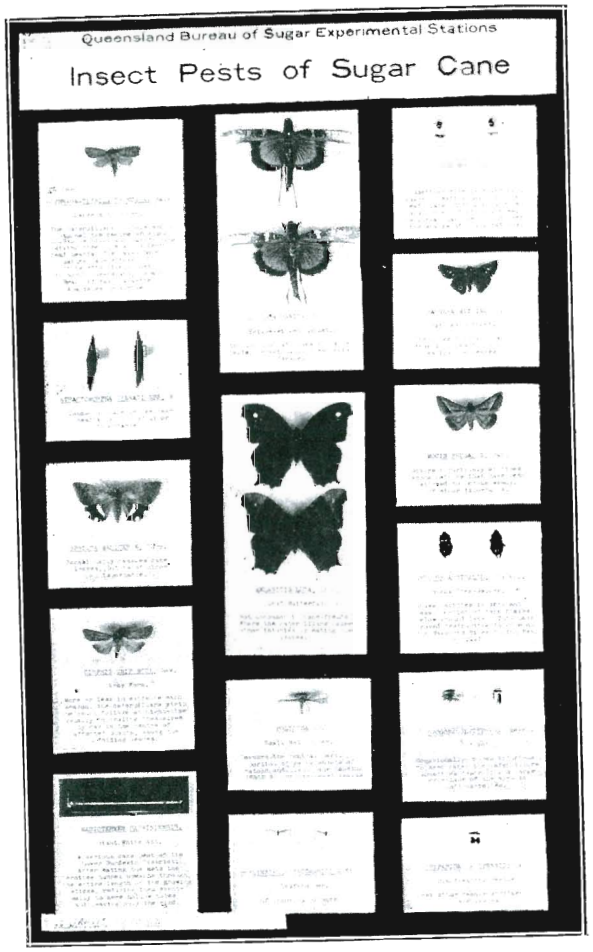


Photo., Jarvis and Burns.

Show-case, containing Minor Cane Pests destructive to the sticks and leaves.

upon by the air does not deliquesce, but very gradually volatilises, thus allowing the gas ample time in which to impregnate the entire strip of soil occupied by the main roots of the cane-stools.

Crude and cheaper forms of this chemical appear just as effective against cane-grubs as the refined qualities. One of these crude forms, when opened up upon arrival here, was found to be quite moist, and of a pale greenish yellow colour, while the fumes given off, in addition to possessing the usual characteristic pungency, emitted an odour distantly resembling that of burnt sugar. Although such moisture soon vaporises, the sugary smell has remained unaltered after a lapse of more than two years.

WORK WITH PARADICHLOR. IN AMERICA.

It is interesting to note that in 1915, while the present writer was conducting first experiments with this fumigant against cane-grubs at Gordonvale laboratory, it so chanced that control work was also being commenced at the same time, with this chemical and other toxic gases, by the Bureau of Entomology at Washington, in hopes of discovering some means of combating larvæ of the peach-borer (*Ægeria exitiosa*), an insect causing injury each year amounting to 6,000,000 dols.

As a result of these experiments, carried out during several seasons, Mr. E. P. Blakeslee clearly demonstrated that paradichlor., when properly used, was uniformly effective against the peach-borer; and in a recent publication issued by the United States Department of Agriculture (Farmers' Bulletin No. 1246) he states as follows:—

> "There has now been accumulated a sufficient body of experience, based on large-scale commercial use, and further experiments by the Bureau and others, principally the New Jersey Experiment Station, to show that a practical economic method of control has been found for this heretofore invulnerable pest."

Reverting to our own experiments with paradichlor., we also are now in a position to announce that the worst insect enemy of the Queensland cane-grower—the dreaded greyback cockchafer (*Lepidoderma albohirtum* Waterh.)—has at last received a severe blow, the economic significance of which will doubtless be far-reaching, and cannot fail to be ultimately realised by all who are aware of the tremendous annual loss to our sugar industry (amounting, it has been estimated, to tens of thousands of pounds sterling) due to the ravages of this well-known cane-beetle.

August to September 1924.

CALCIUM CYANIDE VERSUS CANE-GRUBS.

Additional data in connection with the possibilities of hydrocyanic acid as a fumigant against scarabæid larvæ have been obtained this month (supplementary to that already reported in the "Australian Sugar Journal," vol. xv., p. 708; xvi., pp. 66, 325).

PLATE IX.

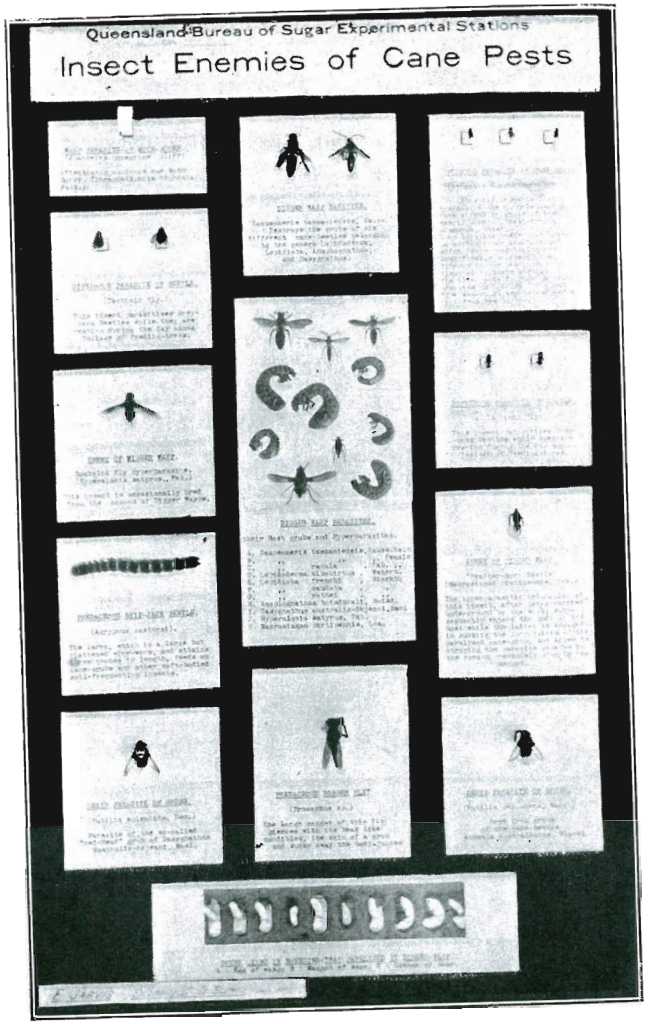


Photo., A. N. Burns.

Show-cases, containing Hymenopterous and Dipterous Enemies of Queensland Cane-grubs.

In a previous report it was stated that a dose of 60 grains of calcium cyanide (30 grains on each side of the plant) did not injure young cane-shoots from 12 to 18 in. high.

Continuing these field tests, further injections of from 80 to 200 grains per plant were administered between the dates 25th June to 21st July (6 in. from centre of plants and 6 in. deep), without harmful effect on cane so treated. When examining these plots on 6th September (47 days later), plants that had received 120 and 200 grain doses were found to be quite normal, and appeared to have made better growth if anything than control plants alongside in the same row.

The above experiments were intended as a crucial test, in order to make absolutely sure this poisonous gas would not damage growing cane-roots. Now, in laboratory experiments conducted last February against grubs confined in cages of soil, we secured a mortality of 100 per cent. from injections of only 15 grains. Assuming, therefore, that in field practice even double this quantity (30 grains) should be required to destroy all grubs under a stool, we could still, if necessary, apply more than ten times that amount per stool without injury to the cane.

We may gather from data already obtained that this fumigant is well worthy of future study and experimentation as a possible controlling agent against grubs of our greyback cockchafer.

The cost of treating an acre with calcium cyanide flakes works out at about £2 15s., which would allow for injection of 8,580 stools with doses of 30 grains per stool.

FIGHTING THE SUGAR-CANE TERMITE.

The white-ant problem on the Burdekin is receiving attention at our hands, the activities of the large termite *Mastotermes darwiniensis* Frogg. having caused considerable anxiety of late to growers at Jarvisfield and elsewhere.

We are experimenting at present along two lines of control, both of which are yielding encouraging results, and may warrant our carrying out field tests later on. The most promising of these is fumigation of the soil with paradichlor. at planting time, or directly the young shoots appear above ground. Such injection would undoubtedly protect sets from invasion by this pest, by rendering earth around the roots repellent throughout a strip of soil 2 or 3 ft. in width, during a period of at least two months. This would allow stools to become well established and better able to resist attacks that might come later on.

(1) *Fumigation with Paradichlor.*

On 26th August an experiment was carried out to determine the effect of paradichlor. on larval and soldier forms of *Mastotermes darwiniensis* Frogg. Twelve cages of moist soil, each containing fifty

white-ants buried about 3 in. deep alongside a small section of cane-stick, were prepared; five of these cages being treated with $\frac{1}{32}$-oz. and five with $\frac{1}{16}$-oz. doses of crude paradichlor., while two cages were used as controls. The fumigant was buried about 2 in. above the termites.

Photo., G. Bates.

Portion of Cane-stick harbouring specimens of *Mastotermes darwiniensis* Frogg. (Nat. size.)

Four days later, upon examining two of the cages given the smaller dose, 25 termites were found to be in a moribund condition, and the remainder dead. An examination of three cages that had received the

bigger dose showed all termites dead, some being in an advanced stage of decomposition. Inspection of the remaining six cages on 2nd September (one week from date of application of fumigant) gave a mortality of 100 per cent., while white-ants in controls remained perfectly normal.

This experiment was repeated with very similar results on 9th September, twenty treated and five control cages being used, each containing 20 specimens of *Termes meridionalis*. This species was more quickly affected by fumes of paradichlor. than *darwiniensis;* most of the workers, soldiers, and nymphs of the former being found dead forty-eight hours after application of the $\frac{1}{32}$-oz. dose.

(2) *Dipping Sets in Arsenical Solutions.*

The chief arsenicals being tested here at present for controlling white-ants are lead arsenate and arsenate of copper. The former, although less deadly, has the advantage of being much cheaper and not so dangerous to handle. Four strengths of lead arsenate were tested, viz., from 1 to 4 lb. of the poison in 24 gallons of water.

Short pieces of cane-stick, after immersion in the various solutions and well shaken about to ensure an even wetting of all portions, were first allowed to dry and then placed in cages of soil, each containing five specimens of *Termes meridionalis*. Sets were placed 2 in. from bottom of cages, and the termites an inch below these buried pieces of cane. A couple of cages of the 1 lb. in 24 gallons water, and two cages of the 2 lb. in 24 gallons, were examined after a lapse of four days, when all of the white-ants in these cages were found to be dead. The remaining sixteen cages were opened up after a further interval of four days, with exactly similar results, every termite being dead; while all those in the five control cages were alive and healthy.

The above-mentioned results apparently indicate that the termites in each cage had worked towards and discovered the sets, and then attempted to eat or tunnel into them.

Cane Pests of Burdekin District.

This district was visited last August in order that control work might be instituted against cane-grubs and other insect pests, that during the past season have done rather serious damage to cane in certain localities. An assistant was instructed to proceed to Ayr, and, in collaboration with the secretary of the Lower Burdekin Pest Destruction Board, carry out fumigation work with carbon bisulphide against grubs of the greyback cockchafer, and at the same time test the effect of this fumigant upon the large white-ant *Mastotermes darwiniensis* Frogg.

Grubs had finished feeding but had not pupated, and were located at depths varying from 4 to 18 in. Rows of cane measuring collectively a length of about 10 chains were fumigated on one farm where the soil was of a sandy-loam character. Injections of carbon bisulphide were made from 12 to 18 in. apart and 9 in. deep, just above the grubs that were lying at an average depth of 10 in. from the surface. Twenty-four hours after application of this fumigant, six stools were dug up from a row where injections were 12 in. apart, and yielded grubs at depths of 8, 6, 13, 12, 10, 12, 12, 7, 10, and 14 in., all being dead. Five stools from a row where injections had been made 18 in. apart yielded grubs at depths of 8, 12, 11, 16, 8, 18, 9, 8, 16, and 14 in., all of which were dead.

The ravages of the large white-ant were of a serious nature on some farms. Cane planted in May and during July and August was reported as being very subject to attack, and on low-lying alluvial flats this pest was observed damaging both young and old cane. On a 5-acre block of Badila, situated along the bank of a creek cleared in 1913, where termites have been troublesome for the last three years, the proprietor estimates a loss this season of about 10 tons per acre. *Note.*—Growers should refer to the heading "Fighting the Sugar-cane Termite" in another portion of the present report.

Fumigation of termite-infested stools was carried out on one of the cane-farms, by applying the bisulphide on each side of some affected rows of cane; while injections of 1 dr. 55 min. were put in 4 in. from plants, 4 in. deep, and 12 in. apart. When digging under stools a few hours after application, all the termites unearthed were dead; but a couple of days later, when digging up treated stools, live termites were found in every case, and no odour of bisulphide could be detected in the soil. This may have been due to fresh invasion of these stools by termites located outside the fumigated strip, since fumes from this insecticide are not deadly for much longer than twenty-four hours after application in some classes of soil, especially during dry weather when the ground is very open for fumigation. On the other hand, it is possible for many of the white-ants to escape the influence of such treatment, owing to failure of the fumes to penetrate into closed tunnels, &c., in the sets or basal portions of stools.

The large moth-borer occurred rather plentifully in young shoots of ratoon and plant cane. Various other insect pests of minor economic importance were observed during our visit to this district.

September to October 1924.

RESULTS OF PAST EXPERIMENTATION.

Reviewing the cane-grub situation by the light of comprehensive data obtained during research work continued for the past ten years, we are now in a position to state that in the writer's opinion our chief offender, the well-known greyback cockchafer, is best controlled during the larval and imago stages of development.

As a result of careful consideration of the numerous methods of combating the various life-cycle phases of this pest, I may state that those applicable to the grub have proved the most promising up to the present. Such control methods can, if desired, be practised throughout a period of from two to three months, while these larvæ are passing through their first and second instars, before they have been able to appreciably damage the cane; moreover, the grower has the satisfaction of knowing that destruction of the grubs attacking any particular crop in December and January (after disappearance of the beetles) means that any cane so treated is certain to yield maximum results, since no additional infestation of grubs can possibly occur until the following year.

Commenting on the various remedial measures outlined in a previous monthly report, for March 1915 ("Australian Sugar Journal," vol. vii., pp. 140-41), it may be stated that, while one or two of these still offer a wide field for future research, the following stand out as being well within the reach of our cane-growers:—

(3) Collecting grubs by hand wherever practicable, both from behind ploughs and under trash in wet weather.

(4) Fumigation of the soil with a gas deadly to animal life, but having, if possible, a stimulating effect on vegetation.

(8) Encouraging vigorous root development and conditions favourable to conservation of moisture, by judicious manuring and thorough cultivation.

(10) Maintaining the soil in a friable state, and free from weeds throughout the growing season.

It is encouraging to be able to announce that investigations carried out during the last couple of years regarding the possibilities of measure No. 4 have yielded positive results, both in laboratory and field work, and might now be said to have arrived at a focus, as it were; fumigation of the grubs during their first and second instars having been accorded chief place.

Carbon bisulphide has been used for many years in our Northern canefields, and when applied intelligently and at the right time good results appear to have followed. Its use, however, instead of becoming more general, has decreased of late owing to various causes that need not be discussed here. In some other sugar-growing countries, Porto Rico for example, where it was used in 1918 for combating grubs of *Phyllophaga* and *Phytalus*, it proved disappointing, and when doses exceeding 12·5 c.c. were employed was found to injure the cane, "stunting its growth and often killing the plant."

PLATE X.

E. Jarvis, del.

Photo., E.J. and A.B.

Diagrammatic drawing of Third-stage Grubs of *L. albohirtum* devouring basal portion of cane-stools, during April and May.

Up to the present our experiments with soil fumigants have shown that paradichlor. is entitled to take first place as a controlling agent against the grubs of our principal cane-beetle. Calcium cyanide is likely to prove equally effective; laboratory tests on grubs confined in cages of soil having given startling results. No definite opinion, however, can be given until this fumigant has been experimented with in the field.

NATURAL CONTROL CHECKING NUMERICAL INCREASE OF CANE-BEETLES.

The past season has proved a lucrative one for our Northern cane-growers, insect pests having on the whole given little or no trouble. This, as stated in my Annual Report for 1923-24 (the following extract from which may interest cane-farmers) is owing mainly to the normal activities of our greyback having been restricted by adverse climatic conditions experienced in the Cairns and Babinda districts during the last two years.

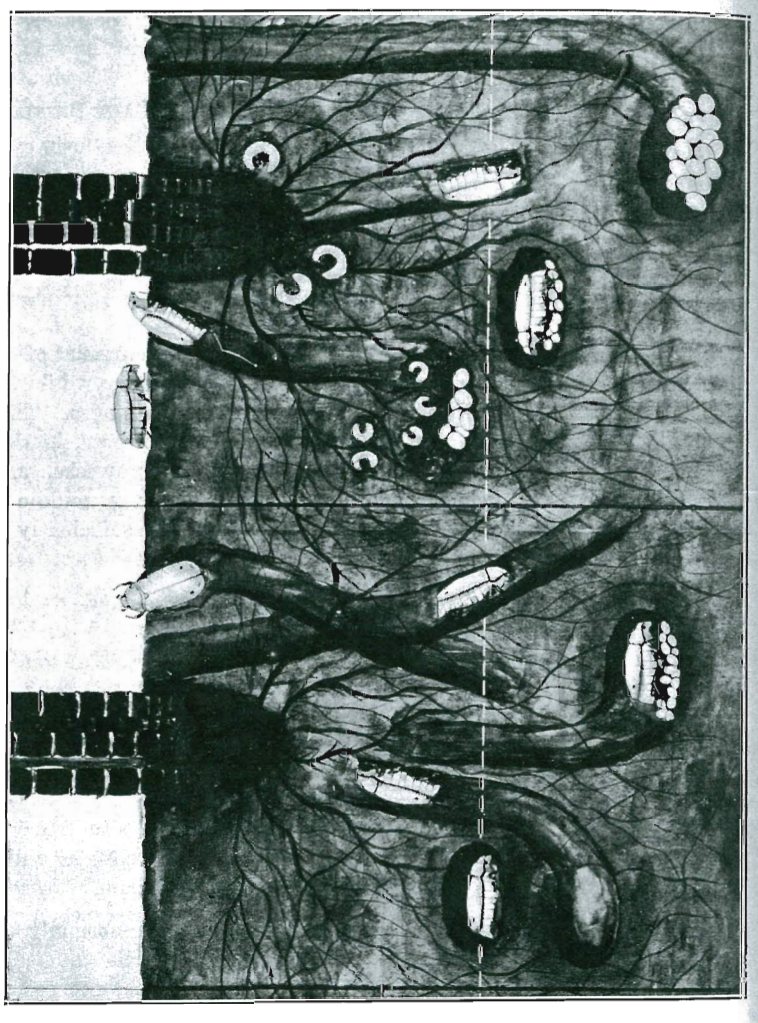
> "Such check was due in both seasons to the occurrence of dry weather throughout the period September to January, while this insect was passing through its pupal and imago stages. These beetles usually emerge in October, remaining, however, in their subterranean pupal chambers for three or four weeks, until thundershowers—which generally arrive about the middle of November—have moistened the hard, dry soil sufficiently to enable them to tunnel to the surface."

Unless rain chances to fall before the first or second week in December, countless numbers must inevitably perish through inability to reach the feeding-trees. In 1922 the total rainfall for Cairns district during a period of five months, September to January, was 7·65 in., while the average precipitation for that period was 34 in. To make matters worse for the imprisoned beetles, 10 points only were recorded in November instead of 413 points, the usual average for that month; and during December of the same year 197 points as against the average of 919 points. These two months, which happen to cover the most critical period in the life-cycle of this pest, should have yielded collectively a precipitation of 13·32 in. instead of only 2·07 in.

In 1923, although the situation was a little easier, abnormally dry conditions again operated as an additional check on the numerical increase of this cockchafer, before it could recover from the setback experienced the preceding year. The rainfall was 15·73 in. collectively for the similar period of five months (September to January), as against the average of 33·42 in.

During November of 1923, however, which may be considered one of the most critical months for this species, only 60 points were recorded instead of the average of 403 points; while, to make matters worse, beetles had appeared in the pupal chambers during September, owing to

PLATE XI.



E. Jarvis, del.

Diagrammatic drawing of mode of Oviposition of *L. albohirtum;* showing eggs in egg-chamber, being laid, and swelling prior to hatching; also first and second instars of grub.

grubs having transformed earlier than usual. Thus, a want of sufficient rain in November proved a far greater check on these beetles than would have been the case had pupation of the grubs occurred at the usual time of year.

It is well to bear in mind that when normal seasons again prevail there is every likelihood of this destructive cane-beetle manifesting its maximum activity; more particularly in those districts where practical control measures such as collecting the grubs and beetles have been altogether abandoned.

October to November 1924.

RESULT OF EXPERIMENT PLOTS AT WOREE.

Through the courtesy of Mr. E. C. Earl, these experiment plots were allowed to stand for about a fortnight after the surrounding cane in the paddock had been harvested. When finally cut on 18th September, the crop being then thirteen months old, it was loaded on different trucks in order that cane from the treated and check plots might be weighed separately at the Hambledon Mill.

As a result of figures supplied by the Colonial Sugar Refining Company, it may interest growers to learn that the area ($\frac{1}{8}$ acre) fumigated with paradichlor. yielded 3·410 tons of cane, equal to 27·208 tons per acre; while the grub-affected cane from the check-plot of similar area weighed 1·755 tons, representing 14·032 tons per acre. Thus we find from the above figures that a gain of an additional 13·428 tons of cane per acre was secured as a direct result of this treatment.

It must not be overlooked that increased tonnage is not the sole benefit one derives from a control measure of this nature, since destruction of the grubs under plant-cane means also the development of healthy ratoons for the following season.

A large percentage of grub-eaten plants on our check-plot at Woree were practically out of the ground, holding merely by two or three roots, which, although able in some cases to keep such sticks alive, could not supply sufficient nourishment for any additional growth, or prevent the gradual drying up of affected canes.

DEGREES OF GRUB-INFESTATION.

Fortunately the grubs in this paddock at Woree last season were confined to large patches of varying extent, such infestation causing some of the stools to collapse in places, but not being severe enough to totally destroy them. Such conditions prevailed in the vicinity of our experiment plots. During really bad seasons grubs will sometimes kill half-grown stools of cane by literally eating them out of the ground. In such cases no amount of subsequent rain can keep the plants alive,

and in a few days every leaf is brown and dead. This calamitous state of things happens occasionally to Badila growing on light friable soils. By using paradichlor. it should be possible to grow good crops of Badila where at present only uncertain crops of D. 1135 are being obtained.

Controlling Grubs by means of Cultural Operations.

The influence of cultivation in connection with cane-grub control has been briefly touched on from time to time in my early reports; although up to the present the various field operations calculated to reduce grub infestation have not been enumerated collectively. It may be well, therefore, to mention a few common-sense means of combating this pest during its early larval condition, when occurring on small areas known from past experience to be liable to infestation:—

(1) Try to have the soil between cane-rows loosened up and free from weeds by the time greybacks appear on the wing, maintaining such cultural conditions for at least one month from date of emergence of the beetles.

By so doing one takes advantage of a habit common to cockchafers, of ovipositing by preference in undisturbed ground, the hard surface of which affords a kind of fulcrum, enabling the beetle to easily maintain its correct position, assumed while digging in. A surface consisting of loose particules is not so readily entered, such soil naturally tending to impede progress of the insect by continually falling into its tunnel during the process of excavation.

(2) Work the soil close to cane-rows while grubs are in the first instar, and quite small. This period, which commences about a month after first appearance of the beetles, occupies from five to six weeks.

Advantage may thus be taken of the habit common to first-stage grubs of *albohirtum*, of feeding close to the surface within 3 to 6 in. of cane-stools. This position brings them within reach of agricultural implements, and, by stirring a strip of soil about 12 in. wide as close to stools as one can go with safety, many of these small grubs will be killed, since those sustaining minor injuries due to compression of the soil, jars, abrasions, &c., usually die a few days later. Planet Junior implements are suitable for such work, and it would pay the farmer to run through a small patch several times in the manner described above at intervals of a few days.

(3) Encourage vigorous root development and conditions favourable to conservation of moisture, by judicious manuring and thorough cultivation.

Such fieldwork not only ensures an increased yield of cane, but has a decided influence also on any third-stage grubs that may be present during the month of February on land where the cane-leaves have not

met between the rows. Stools surrounded during this period by a dense mass of fibrous feeding roots—such as one finds near the surface in well worked and manured soils rich in humus—suffer less danger as a rule from grubs than is likely to occur among poorly cultivated cane. These upper roots are generally the first to be devoured, and, unless an infestation chances to be severe, vigorous stools in rich, well-worked soils are able to make additional roots almost fast enough to take the place of those being eaten. Grubs are very fond of these tender, succulent roots, and generally finish every one before attacking those lower down which supply moisture to the plant, and being stout and cord-like enable the stools to get a firm grip of the ground.

I have previously pointed out (Bulletin No. 17, p. 57) that larvæ of our greyback are not primarily humus-feeders to the extent often presumed by growers and others, but subsist very largely on living vegetable tissue; hence the habit noticed above common to its first-stage grubs, of feeding near the surface on young, fibrous cane-roots. Humus, however, while helping to keep the top soil in good mechanical condition for retention of moisture during hot weather, has an influence, indirectly, upon grub activity; since, by promoting abundant development of surface roots, attack on the more vital lower and basal roots is often delayed long enough to save destruction of the crop.

(4) Keep fallow land reserved for early planting free from weeds during December to January, while cockchafer beetles are engaged in egg-laying.

A luxuriant growth of vegetation between the rows is strongly attractive to egg-laden females of *albohirtum* and *frenchi*, which usually oviposit during December and January. Grubs of the greyback attain full growth in the space of about six months (January to June), pupating as a rule from July to September.

Those of *Lepidiota frenchi*, on the other hand, remain in the larval stage for nearly a year longer, both second and third stage grubs of this species being procurable during winter months; damage to cane, however, occurring every second year when the majority of its larvæ are in the third instar and fully grown. This cockchafer oviposits freely on grass land or among weeds, with the result that, when ploughing for an early crop, the grubs from eggs laid in such situations, being about five months old and still small, are often overlooked or allowed to remain in the soil. As a matter of fact, however, these young larvæ have still about a year to pass before pupating, during which time they are able to cause appreciable injury; moreover, after such infested land has been planted and the weeds destroyed, they are necessarily obliged to subsist almost entirely on the roots of the cane.

November to December 1924.

Appearance of Cane-Beetles.

Cane-beetles (*Lepidoderma albohirtum* Waterh.) have emerged in considerable numbers this season, and, judging by data obtained from Highleigh, Hambledon, Woree, and other localities, damage to cane from grubs of this pest is likely to be greater than that experienced during the 1922-23 season. At the present time (12th December) the eggs of *albohirtum* which, in districts where 3 to 6 in. of rain were registered about the middle of that month, were laid about the end of November are now commencing to hatch out, and in such localities the resultant grubs will be found in the first stage of growth from the middle of December to middle to January.

How to Distinguish Instars of Grub.

Larvæ of the greyback may be distinguished at a glance during their first instar by their small size, since they then measure only from $\frac{1}{4}$ to $\frac{1}{2}$ in. in length across the doubled-up body; the head being never more than $\frac{1}{8}$ in. wide. Later on, after moulting into the second instar, they are from $\frac{5}{8}$ to $1\frac{1}{3}$ in. in length longitudinally, while the head is then $\frac{1}{4}$ in. in width.

The simplest way, indeed, of distinguishing between grubs of the first, second, and third instars is merely to examine the head, since this, unlike the rest of the body, does not increase in size during the course of the various instars, altering only when a grub moults or casts its skin. After the second moult, for example, the head attains its maximum width, viz., $\frac{3}{8}$ in., never growing larger; although a grub during the period occupied by its third instar more than doubles the size and weight of its body. Growers would do well to make a mental note of these head widths of $\frac{1}{8}$, $\frac{1}{4}$, and $\frac{3}{8}$ in.

When to Fumigate Cane-Grubs.

Second-stage grubs of *albohirtum* will probably be feeding this season until the middle of February; so that, in the event of weather conditions proving favourable for fumigation of the soil, grub-infested cane land could be treated up to the end of that month. Having experienced a rather wet December, the so-called rainy season may not set in as early as usual, in which case the ground might not, as often happens, be too wet for such fumigation throughout February.

Cane-Boring Longicorn Beetle.

In connection with the work of breeding tachinid fly parasites of *Rhabdocnemis*, larvæ of what appeared to be another species of beetle-borer tunnelling in cane-sticks infested by the former insect were brought to light. The first of these larvæ, found at Highleigh last year, happened

to be in standing cane, and when bred to the imago condition proved to be that of *Prosoplus misellus* Pasc., one of the Cerambycidæ or longicorns; a little beetle only $\frac{3}{8}$ in. long, dark-brown in colour, obscurely blotched with grey, and wtih its antennæ scarcely as long as the body. When placed in a cage containing a piece of fresh cane, it did not, however, attempt to bore into this, and ultimately died without having entered the stick. Additional examples were subsequently collected by Mr. Bates, both at Macknade and Proserpine, in old, fermenting cane-sticks.

An Interesting Insect Pest of Sugar-Cane.

On 20th November a beetle-borer of cane was brought under my notice by Mr. Horace McGuigan, of Sawmill Pocket, who had observed that a small patch of his young ratoons from 10 to 15 in. high were affected by some strange or unfamiliar insect pest, the tiny larvæ of which were discovered by him boring inside the shoots, causing death of the central leaves. Examination of such infested ratoons, submitted by him for my inspection, revealed the presence externally of tiny, cleanly cut holes $\frac{1}{16}$ in. in diameter, pierced in the sides of shoots from 1 to 3 or more inches above ground level.

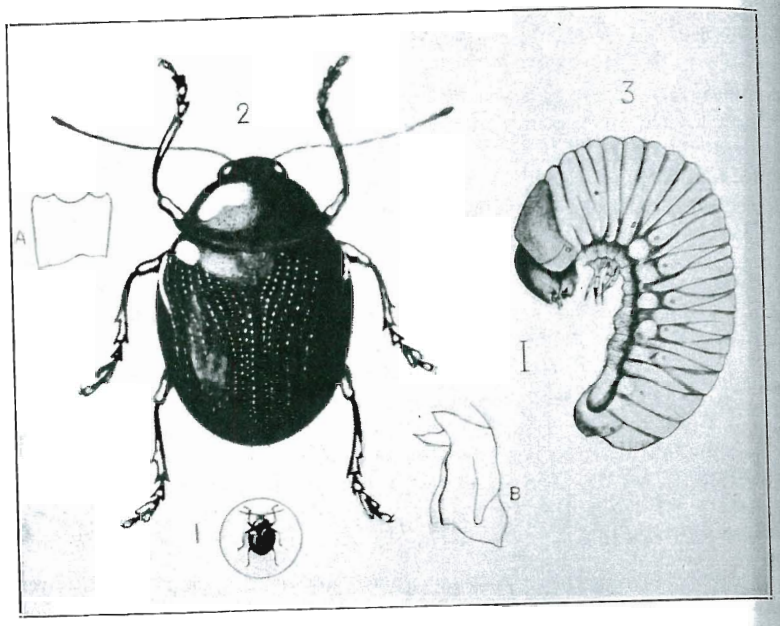
Buried among this débris in the first shoot examined was a plump pinkish-white grub about 3·50 mm. long by 1 mm. in width, which, like many coleopterous larvæ, was able when removed to crawl rather quickly over the ground on the ventral surface of its body.

Specimens of these larvæ were transferred to healthy cane-shoots, into which they soon commenced to bore. Nine days later they left the cane and burrowed into moist soil in the bottom of their breeding-cages, in order to pupate.

Strange to record, a few days after discovery of this insect, the presence at Proserpine of a pest doing very similar damage to young plant cane at Kelsey Creek and Waterson was brought under notice of this experiment station by Mr. G. Bates.

At Proserpine these grubs are said to attack the eyes of cane-sets, tunnelling also into the newly sprouted shoots below ground when only a few inches long. During August and September thirty or more specimens are reported to have been found under a single stool of cane.

The species in question proved in both cases to be *Rhyparida morosa* Jac., belonging to the Chrysomelidæ, a family which includes a vast number of small leaf-eating beetles, very many of which—such as our well-known species of *Aulacophora* attacking cucurbitaceous plants, or *Monolepta, Nisotra*, and other genera affecting fruit trees, &c.—are of great economic importance. It will be well to mention here that this species has previously been recorded by the writer as being a leaf-eating and cane-boring insect ("Queensland Agricultural Journal," vol. xiii.,



E. Jarvis, del.

(1) *Rhyparida morosa* Jac (nat. size).
(2) The same, magnified. (A) Labrum of same; (B) mandible of same, magnified.
(3) Larva of same, magnified.

p. 274). Although described for the first time as a cane-pest in 1915 (Bulletin No. 3 of this Office), the larvæ of *Rhyparida morosa* Jac. were not found until five years later. This occurred whilst studying the economy of our smaller moth-borers, when one out of many "dead hearts" examined was seen to contain a coleopterous larva that had eaten a central tunnel in the base of a cane-shoot. This grub was placed in a breeding-cage, and on 25th January (nine days later) transformed into the beetle condition. At the same time several specimens of the larvæ were discovered by the writer tunnelling in the succulent basal portion of stems of blady-grass (*Imperata arundinacea*) at Pyramid. Upon tearing off the loose, brown basal sheathing of these affected stems, a hole in the side about $\frac{1}{16}$ in. in diameter was exposed to view, out of which, before many seconds, a larva, if at home, usually emerged hastily, tail foremost, and endeavoured to escape. By the help of its spined tail and several transverse rows of abdominal bristles this larva is able to crawl rather quickly over level ground.

This very common little beetle is about $\frac{1}{4}$ in. long, of convex shape, and uniformly black and shining, occasionally with a bronze tint. Its head is concealed nearly to the eyes in the prothorax, and the antennæ

are reddish brown with eleven joints of about equal length, the first being lighter in colour, more slender, and less hairy than the remainder. The prothorax and elytra are punctulate, the former irregularly and finely, the latter coarsely, with the punctures arranged in curved lines as indicated on page 62, Fig 2; scutellum semi-circular. Length of body 6 mm., greatest width 4 mm. During the heat of the day these beetles may be found resting deep down between unfolding heart-leaves of cane, and feeding openly on the leaves of blady-grass.

After learning of the occurrence of this beetle at Proserpine I was surprised to receive additional specimens of the larvæ of a Chrysomelid beetle from Mr. T. J. McMillan, secretary of the Queensland Producers' Association at Stone River, in the Herbert district, reported to be damaging young plant-cane. Unfortunately, however, these specimens, which were probably examples of *R. morosa,* were too much damaged by ants, after receipt of same, for identification of the species.

To receive complaints regarding this little cane-pest from no less than three widely separated districts during a period of less than a month appeared at first sight somewhat disconcerting. Possibly, however, certain of our growers, having taken notice of the publication of our Monthly Hints about cane insects, may have been on the lookout for indications of moth-borers in their young cane, the presence of which being betrayed by "dead hearts" would naturally lead in time to the discovery of the little beetle-borer in question, which causes injury of a similar appearance.

Rhyparida morosa is not likely to become a serious cane-pest in the future. Headlands, however, should be kept free from blady-grass, as when this is allowed to grow close to cane-rows these beetles are liable to invade such plantations, and in some cases may gradually acquire a liking for the foliage of sugar-cane.

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A. J. Cumming, Government Printer, Brisbane.