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DIVISION OF ENTOMOLOGY.
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Notes on Queensland Cane-Insects and their Control.

BY

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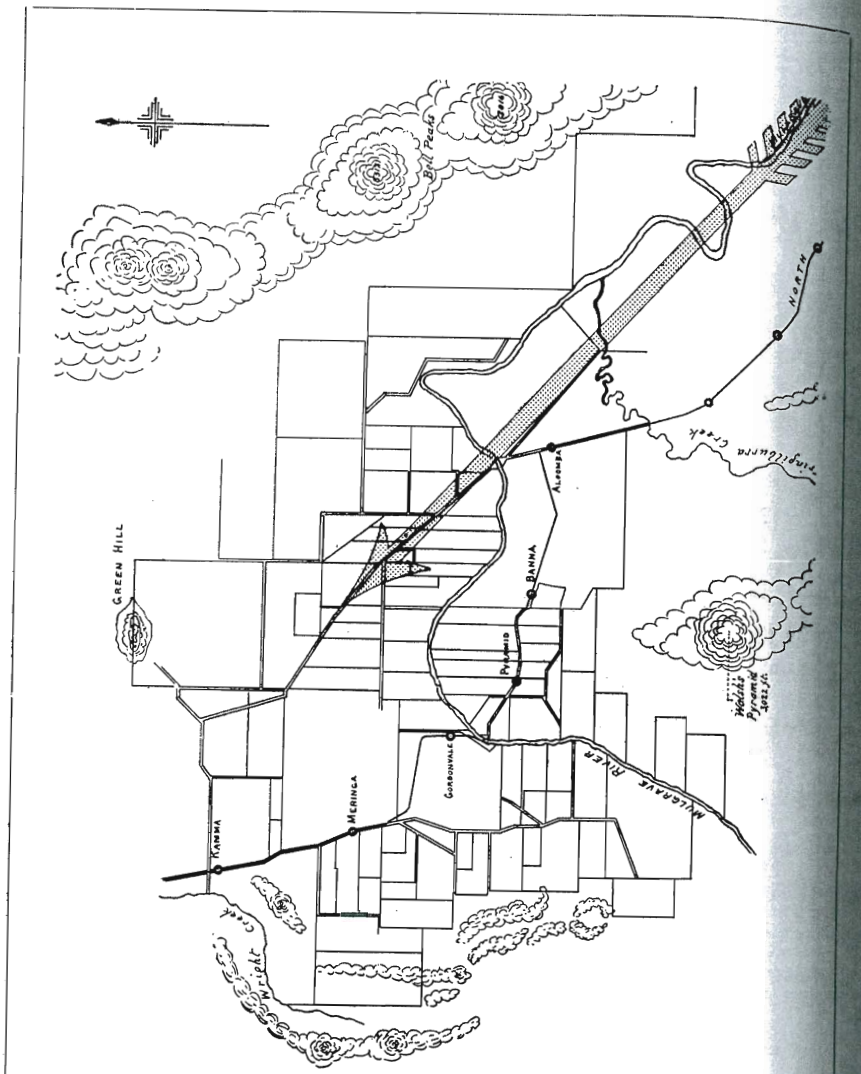
FOREWORD.

Bureau of Sugar Experiment Stations,
Brisbane, 31st December, 1923.

THE following notes on Queensland Cane-Insects have been prepared by the Entomologist of the above Bureau (Mr. Edmund Jarvis) from monthly and other notes published by him from time to time in the Press. They will be found exceedingly interesting and instructive to all cane-growers. The series thus collected will form Bulletin No. 17 of the Bureau.

H. T. EASTERBY, Director.

PLATE I.



AREA OF CANE LAND THAT IS USUALLY GRUB-INFESTED EACH SEASON ON THE NORTH-WEST PORTION.

For description of beetle invasion of same, see pp. 44-45. The arrow indicates direction of south-east trade wind.

Notes on Queensland Cane-Insects and their Control.

By EDMUND JARVIS, Entomologist.

INTRODUCTION.

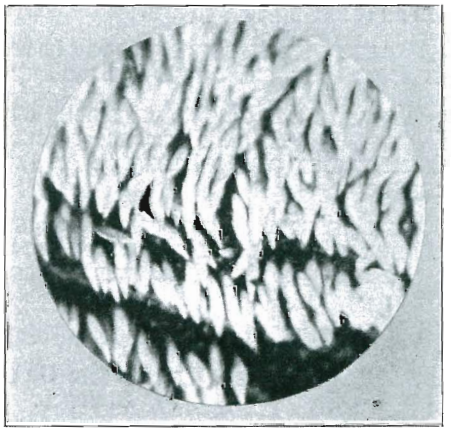
THE information embodied in this Bulletin has already appeared from time to time in the form of Monthly Reports, extending over a period of about four years, viz.:—September 1914 to June 1917; and June 1921 to June 1922.

Being scattered, however, through the pages of our "Agricultural Journal" and other periodicals, much valuable data regarding methods of controlling Queensland cane-insects, original modes of investigation, and details of experimental work in the laboratory and field, have practically been lost sight of; hence publication of these notes in a form which it is hoped will render them readily available for reference purposes.

The chief activities of this Entomological Station have been directed against the notorious "Greyback" cockchafer (*Lepidoderma albohirtum* Waterh.), an insect which I have addressed in the following lines:—

Dread ravager of waving seas of cane,
Strange scaly creature, lowly yet supreme;
Cursed, but triumphant, fast attaining fame,
Haunting our growers like some evil dream.

"GREY" OR "MEALY BACK" COCKCHAFER (× 1½).



PORTION OF WING-CASE, SHOWING COVERING OF WHITE PEAR-SHAPED SCALES (× ABOUT 90 TIMES).

Photo., W. C. Dormer.

What earest thou, grey spectre of the night,
For man's distress; or though his hard-won gold
Be lavished in prolonged unequal fight
Against thy feeble grub? Ages untold

Have watched thy countless hosts awake each Spring,
Crawl from the steaming earth and take to wing:
Thenceforth 'mong fragrant gums to freely roam,
And taste the glories of their native home.

Meringa Laboratory is situated in the Cairns district, about 900 miles from Brisbane, and within 20 deg. of the Equator; the average annual rainfall being fully 92 inches, while the minimum and maximum temperatures range respectively from 68·4 to 83·7 deg. Fahr.

The land is mostly volcanic in nature, consisting of friable soils varying from light red to chocolate; the latter class—of which Greenhills affords a good example—being as a rule deep and exceedingly fertile. Extensive alluvial deposits, constituting the low-lying river flats, and composed of rich sandy or clay loams, also occur near Gordonvale; such cane lands being of exceptional value and yielding very heavy crops.

Since the first appearance of some of the earlier reports issued during 1915-17, the scientific names of certain insects alluded to at that time have been determined, or in some cases revised; and these additions or alterations, as the case may be, have accordingly been brought up to date.

A number of interesting and original illustrations, the majority of which have not hitherto been published by our Sugar Bureau, are included; and these, together with the addition of a comprehensive index, should add greatly to the usefulness of the present bulletin.

All localities of infestation, unless otherwise specified, are to be taken as referring to Meringa.

The surrounding country, as will be seen by the accompanying map, is uniformly flat, and almost encircled by mountain ranges.

The vegetation consists principally of eucalypts, acacias, tristanias, melaleucas, figs, &c., with an undergrowth of coarse grasses, lantana, and herbaceous plants belonging to the genera *Sida, Malvastrum, Urena,* &c.

Descriptions of general colouration, sculpture, structure, &c., when applying to field observations, were observed by the aid of an ordinary pocket lens magnifying about twenty times.

September 1914.

First Impressions when Taking Up the Study of Cane-Grub Control.

Upon reviewing the Cane-grub situation in the light of past investigation at Gordonvale, it becomes apparent that the time has arrived for instituting several definite lines of action against this pest. Up to the present, research at the laboratory has been mainly devoted to a very necessary study of the life-cycle and metamorphosis of the most injurious of our cane-beetles, *Lepidoderma albohirtum* Waterh. and several closely related destructive species.*

This branch of work will be continued, but supplemented by more extended field investigations regarding the adult stage of *albohirtum* and other cockchafers known to be of economic importance.

The value of such field-work cannot be over-estimated, affording as it does the possible discovery of some peculiar habit, exposing, perhaps, a weak point that can be taken advantage of for the purpose of attracting, trapping, or otherwise destroying vast quantities of the beetles. We must not lose sight of the fact that in economic problems, such as that now facing us, leading entomologists have always considered ideal remedial methods to be those in which we succeed best in capturing the females before they have had time to deposit eggs. Various modes of procedure in connection with this leading branch of control are being planned at the laboratory, and experimentation will be commenced upon the first appearance of the adult insects. I am of opinion that the oviposition of *albohirtum* should be closely studied, as this, according to Girault and Dodd (Bull. No. 2 of this Office, p. 20), and the first larval stage, are passed comparatively near the surface, and more easily reached than later larval instars, and the pupal form. It is proposed, therefore, to experiment with various chemicals and thoroughly test their insecticidal effect on subterranean insects, but more especially in the hope of discovering attractive poison-baits for both the grubs and beetles.

The question of parasitic control will not be neglected, although, our cane-beetles being native species, it naturally follows that existing relations between them and their many enemies have been carefully adjusted by Nature in such manner as to enable each insect to multiply in proportions suited to its own peculiar requirements.

The cultivation of large tracts of forest land has apparently enabled this pest to breed in abnormal numbers, but at the same time these artificial conditions, whilst seemingly congenial to the increase of such parasites as "digger-wasps," have probably proved favourable also to the hyperparasitic enemies of these useful insects, viz.—a species of bee-fly *Hyperalonia satyrus* Fabr., and a so-called "feather-horn beetle" named *Macrosiagon pictipennis* Lea. Data collected at our laboratory give the average infestation of cane-grubs by the digger-wasp *Campsomeris tasmaniensis* Sauss. in the Mulgrave district during the last two years as not much more than 1 per cent., whereas in 1902 Tryon recorded local infestations of 25 per cent. on a farm near the Mulgrave River and 10 per cent. at South Isis.

With reference to the question of parasitic fungi it is encouraging to note that towards the end of this month I succeeded in infecting grubs of the "Christmas beetle" (*Anoplognathus boisduvali* Boisd.) with the Green Muscardine fungus (*Metarrhizium anisopliæ* (Metsch.) Sor.). When examined after an interval of about ten days they were quite dead, and covered with a luxuriant growth of the fungus. The method of infection was simple, and suitable for practical field application. Further and more comprehensive experiments in this direction are now in hand at the laboratory.

* Bull. No. 2, Div. Ent. Bureau of Sugar Experiment Stations, 1915.

Official Collection of Insects.

With regard to matters of office routine in the future, I would suggest the advisability of forming a collection of our insect pests of sugar-cane, comprising the following classes:—

1. Insects attacking the stem and leaves externally.
2. Insects attacking the stem and leaves internally.
3. Insects injuring the roots.
4. Insects closely related to our more destructive cane-pests.
5. Useful insects, parasitic and predaceous.
6. Insects incidentally associated with sugar-cane.

A reference collection of this kind could be gradually acquired, and would be very useful.

Comparatively few of our cane-pests have been figured or described, and it would, I think, be a good plan to work out the life-histories of the principal species as opportunity occurs, and publish results in illustrated leaflet or pamphlet form, suitable for distribution amongst growers.

Work for the Month.

Much time has been occupied in getting into touch with work at the laboratory, and organising a plan of attack for the approaching campaign. Whilst inspecting, for the Department of Agriculture, a consignment of seed cane imported by the Colonial Sugar Refining Company from New Guinea for trial at Macknade, I was fortunate in preventing the introduction of three insect pests of sugar-cane, not hitherto recorded from Queensland. Two of these were weevils, identified by Lee as *Trachorhopalus strangulatus* Gyll. and *Imaliodes* (?) sp.; while the third, a scale insect, was named by Dr. Rutherford *Aulacaspis major* n. sp.

October 1914.

In addition to the usual routine work, preparations are being made for testing the value of various control methods against the adult and larval forms of our greyback cane-beetle.

Three different cane-beetles have been bred this month from larvæ hitherto undetermined by us, collected last September, viz., two species belonging to the genera *Lepidiota* and *Heteronyx* (?) and an insect named *Somanopterus depressiusculus* Macl.

Mr. A. P. Dodd, my assistant, who is attending to the rearing of beetle grubs, has also obtained pupæ of five undetermined species, from which we hope to breed adult forms. These, including additional larvæ of four others, together with seven adults already identified, make a total of nineteen different scarabæid beetles attacking sugar-cane in the Gordonvale district.

During this month and part of the preceding (September), large numbers of pupæ of *albohirtum* have been ploughed up on red volcanic soil near Meringa. This circumstance is doubtless due to the abnormal rainfall experienced in the Cairns district during August, thirteen days of which were wet: 4·93 inches of rain having been registered for that month as against 1·48 inches, the average during the preceding twenty-seven years.

Such climatic conditions tend to induce grubs to pupate unusually near the surface, and it is worth noting that the occurrence of excessive wet about that time of year may have an important bearing on the question of control; for, should hot weather set in immediately after pupation and continue for a month or longer, the chances are that great numbers of pupæ occurring in light volcanic and sandy soils under plant cane would perish, owing to the earth above them drying out before they were able to assume the beetle stage.

Field Notes.

A few plantations have been visited in order to secure specimens of cane-insects for our office collection; and to note the occurrence of any pests of minor importance, appearing sufficiently injurious to warrant investigation. Several interesting economic insects were met with, and are now being studied at the laboratory.

Most growers are familiar with a tiny active caterpillar that attacks the eyes of standing cane, and often gnaws the surface of the rind near buds. Although doing little or no appreciable damage to hard canes, this moth is proving harmful to the seed of soft varieties.

Bud-Moth of Sugar-Cane.

Whilst at Macknade Mill last month I inspected some canes of Clark's Seedling (H.Q. 426) that were affected by these caterpillars, and the manager, Mr. Wilkinson, informed me that owing to their presence he had recently been obliged to cut 55 cwt. of this variety in order to procure 10 cwt. for planting; and had found it a difficult matter to get sound eyes below about 20 inches from the top of a cane. We examined several stools at the time and noticed that quite young larvæ were able to enter buds, and in many instances had bored through the rind in the vicinity of affected nodes.

This insect was subsequently bred by the writer from caterpillars collected at Gordonvale, and a full account of its life-cycle stages published in our "Queensland Agricultural Journal" (vol. 3, p. 72, 1915). The resting attitude of *Opogona glycyphaga* Meyr. is very characteristic of this species, which invariably lays its antennæ on the surface, in front of the head, in the position shown at G on Plate II. A chalcid parasite, *Stomatoceras gracilicorpus* Girault, has been bred by us from pupæ of this moth

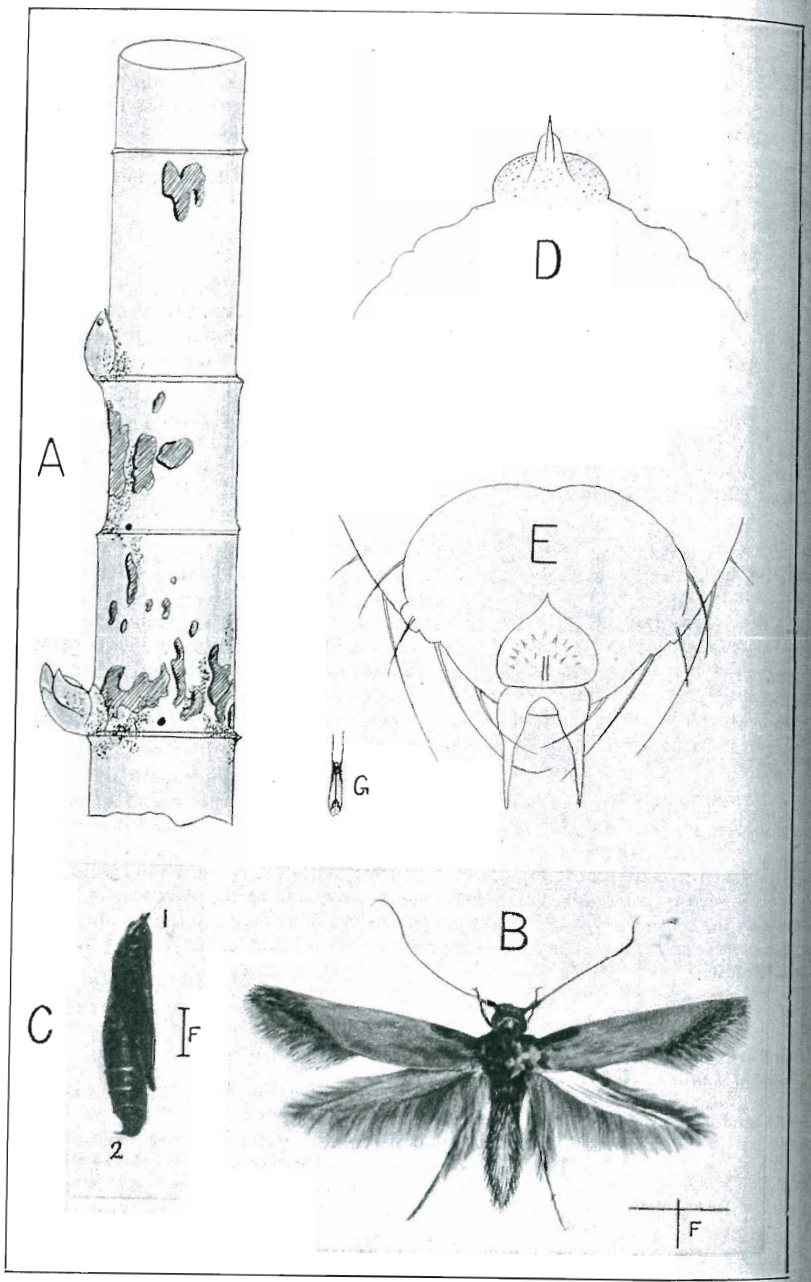
Aphides Attacking Cane.

Little or nothing has been published hitherto regarding our plant lice of the sugar-cane, which, being under efficient natural control, have not occasioned any serious damage up to the present.

I may, however, mention that two species were discovered at Gordonvale during this month, one being evidently *Aphis sacchari* Zehnt., an insect that infests cane in other countries; and the second a species of *Toxoptera*, which has not, I believe, been previously recorded for Queensland. The former frequents mostly the under surfaces of leaves accidentally twisted or bent over by stormy weather, the aphides usually congregating in the folded portions, where they are best sheltered from adverse weather conditions.

This aphis caused no appreciable injury to foliage, but the presence of *Toxoptera* was marked by areas of discolouration of the leaf-blade;

PLATE II.



A—Diagrammatic sketch of damaged cane-stalk.
B—Bud moth (*Logostoma* sp.), magnified five times.
C—Pupa of bud moth, magnified five times.
D—Ventral view of head of pupa at C1, highly magnified.
E—Extremity of anal segment at C2, as seen when pupa lies on its back with end of abdomen turned up.
F F G—Natural size.

the material available for examination, however, being insufficient to furnish conclusive proof of such symptoms having originated directly from injuries caused by these insects.

Both species were much preyed upon by larvæ of a syrphid fly which appeared to be their chief enemy, and by other predaceous insects.

The Army Worm (*Cirphis unipuncta* Haw.) is troublesome just now to young plant and ratoon cane; but fortunately kept in check by its numerous insect enemies.

November 1914.

DEXIID PARASITE OF CANE-BEETLE.

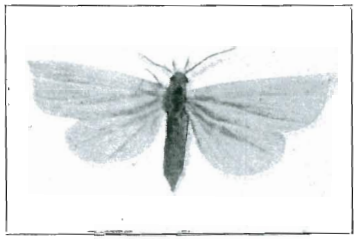
With regard to the question of natural control, I may mention that we have recently bred a dexiid fly (*Rutilia splendida* Don.) from a grub of the cane-beetle *Dasygnathus australis-dejeani* Macl.

The family Dexiidæ includes an assemblage of large, stout-bodied flies of very brilliant appearance, which are parasitic on larvæ of scarabæid beetles. The species in question is not unlike a monstrous blowfly, three-quarters of an inch long, and richly blotched with metallic green and purple. Numbers of these useful insects are at present emerging (25th November) from volcanic soil around Gordonvale, and a few have been captured and transferred to breeding-cages for experimental purposes, to see if they will attack grubs of other cane-beetles.

NEW LEPIDOPTERA AFFECTING CANE.

A noctuid, and tortrix moth of minor economic importance, have been bred this month from larvæ found eating cane-leaves. (*See* Bull. No. 3 of this Office, pp. 25-26.)

The former insect, one of the so-called grass-loopers (*Chusaris rhodias* Turner), was observed last September in the larval stage, associated with the well-known Army Worm (*Cirphis unipuncta* Haw.). It is light yellow, with three reddish-brown dorsal stripes, surrounded by numerous detached zigzag marks of the same colour. The perfect insect, which somewhat resembles *Diatræa saccharalis* Fabr. in size and general appearance, is cream-coloured, with an oblique row of tiny black spots, and a few obscure irregular brown blotches on fore-wings; the hind pair being suffused with uniform reddish-grey tint.



Chusaris rhodias Turner (1½ times nat. size).
Photo., W. C. Dormer.

The caterpillar of the tortrix (*Harmologa* (*miscrana*, Walk.?)) may be easily recognised by the presence of a conspicuous claret-coloured band just behind the head, lighter blotches of the same colour on the back, and four pearl-like pustules on each abdominal segment. As customary with many species of Tortricidæ, the caterpillar feeds under cover, which in the present instance consists of a small piece of the leaf previously bitten off and webbed to a leaf-blade. Neither of these moths has hitherto been recorded as a cane-pest.

Another new and beautiful little moth (*Cosmopteryx* sp.) was also bred last month from larvæ tunnelling the midrib of cane-leaves. This insect, which is scarcely ¼-inch in length, has the fore-wing silvery grey, with two broad transverse yellow bars beyond the middle, that nearest basal area having a single black spot on its inner margin, adjoining a narrow band of metallic silver scales reaching nearly to the centre of wing. Injuries occasioned by this insect are confined almost exclusively to basal portions of the older leaves.

December 1914.

EXPERIMENTS WITH LIGHT-TRAPS.

At the beginning of this month beetles emerged in sufficient numbers to make it worth while commencing observations relative to their movements at night-time; principally with a view to testing the influence of artificial light of various colours on the adult female of *albohirtum*.

It was decided to commence experimentation with an acetylene lamp, fitted with a burner of 28 litres capacity, placed in a beetle-trap specially designed by the writer for this branch of control.

This trap was placed among young plant-cane and the light directed towards scrub land about 100 yards distant; but beetles were scarce, as only three were caught on the 5th instant, and seven during two succeeding evenings. On the 9th and 11th instant, however, a few heavy showers fell, establishing soil conditions conducive to freer emergence of the beetles; and it was then that definite results were obtained, conclusively proving our greyback cane-beetle to be strongly attracted to white light. The following table, recording data during three consecutive evenings, is not without interest:—

Sky clear; no wind; no moon.			*L. albohirtum.*		
Date.	Average Temperature.	Hours.	Beetles Caught.	Male.	Female.
Dec. 14	76 deg. F.	8 p.m.—11 p.m.	51	40	11
Dec. 15	76 deg. F.	8 p.m.— 9 p.m.	57	46	11
Dec. 16	77 deg. F.	8 p.m.—10 p.m.	62	45	17
			170	131	39

Other influencing meteorological conditions are omitted here for the sake of brevity, but it may be mentioned that on the 16th (when 62 specimens were captured) the trap was faced towards the centre of the field, away from feeding-trees, with the object of attracting beetles that might be emerging among the cane. It was remarked that, although they started to fly at the time the lamp was lighted, at 7.20 p.m. the first specimens entered the trap on each of these evenings exactly at 8 o'clock, from which we may infer that *albohirtum* does not readily respond to the influence of artificial light until the last signs of day have faded, and been replaced by a certain degree of darkness.

Having obtained satisfactory proof of the attractiveness of artificial light, the movements and flight of the beetles whilst under influences of a phototropic nature were carefully studied; this being an important

consideration, seeing that no form of light-trap can be of much use unless constructed with view to taking full advantage of the mode of approach manifested on such occasions. It is unnecessary to allude in detail to these observations, but I feel sure that much of the failure during past years has been due mainly to lack of this essential knowledge. Certain conclusions were arrived at regarding the kind of design best calculated to produce a really serviceable trap, and the precise conditions under which such a trap might reasonably be expected to achieve payable results.

It is but fair to state that the total figures tabled above represent only six hours' catch, and would doubtless have been a little higher had the experiment been prolonged throughout the night. Moreover, the single trap used scarcely illuminated one cardinal point of the compass, and it was believed the beetles had not at that time appeared in full numbers. It will be interesting to note during future research whether a few days' exposure to the sun whilst feeding renders adults of this species indifferent to the influence of artificial light. I am inclined to believe that, under favourable circumstances, positive reaction is likely to be continuous; but in any case the beetles are certainly susceptible during their first flight immediately after leaving the soil, and if captured at this time oviposition is prevented. Unfortunately the measure of success obtainable by light-traps is dependent on prevailing climatic and other factors; the beetles at times being disinclined to fly for perhaps several nights, and then suddenly appearing on the wing in vast numbers.

Knowledge of this fact, however, need not deter us from attempting to utilise a method of control which, practised systematically, can hardly fail to be remunerative on badly infested areas. It would be a simple matter to compile a table of directions based on reliable data, from which farmers could tell at a glance when to make use of such traps, and so be saved the time and expense of lighting them to little or no purpose.

LABORATORY NOTES.

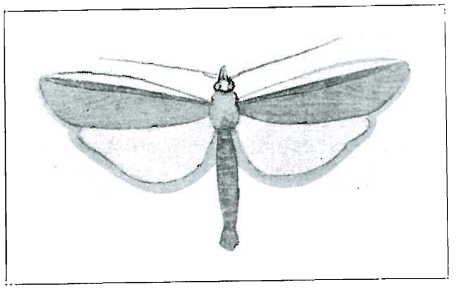
Entomogenous Fungus on Grubs.

Recent experimental work with the Samoan or Green Muscardine fungus (*Metarrhizium anisopliæ* Metch.) has resulted in a 50 per cent. infestation of grubs of our cane-beetle *Lepidiota rothei* Blackb. after a period of twenty-eight days, the first larvæ being killed and covered with fungus spores nine days after infection, while others succumbed to attack a fortnight later. Young larvæ of *albohirtum* will be procurable in about five weeks, when it is hoped to commence a series of experiments similar to the above, to be continued throughout the larval stage of this species. Methods of infection proving successful in the laboratory will, if possible, be tested in the fields at a time of year when weather conditions are propitious to a speedy development of fungus diseases.

Lepidoptera Attacking Cane.

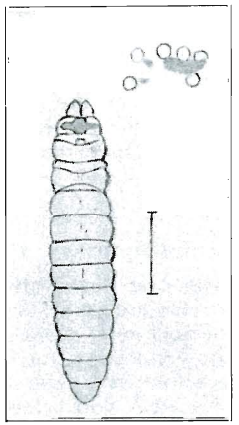
Referring very briefly to the work of breeding and studying the life-histories of economic insects affecting sugar-cane, I may mention that during the past month adult forms of four additional species of lepidopterous insects have been reared from larval forms.

Three of these are butterflies of minor importance belonging to the family Hesperidæ, the caterpillars of which were found destroying foliage of cane-plants near Babinda and at Gordonvale. One of these so-called "Skippers," named *Telicota augias-kreffti* Macl., has been recorded in Java as a cane-pest; while another, *Parnara mathias* Fabr., is known to attack cane in other countries. The third species, *Padraona marnas* Feld., occurs freely at Cairns, Cape York, Kuranda, Mackay, &c. (*See* Bull. No. 3 of this Office for descriptions of larval, pupal, and imago stages, pp. 22-26.)

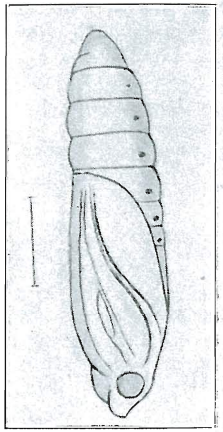


POLYOCHA SP. (TWICE NAT. SIZE).
E. Jarvis, del.

The fourth lepidopteron is a most interesting moth-borer (*Polyocha* sp.) which was observed tunnelling the centre of young shoots of ratoon cane at Pyramid, occasioning injury identical in character with that caused by our large moth-borer, *Phragmatiphila truncata* Walk. Descriptions of the life-cycle stages of this insect will be found in Bull. No. 3 of this Office, pp. 10-11; and Bull. No. 11, p. 10.



LARVA OF POLYOCHA SP.
E. Jarvis, del.



PUPA OF POLYOCHA.
E. Jarvis, del.

January 1915.

Photctropic Reaction of Greyback Cockchafer.

Observations regarding effects induced by acetylene light on alults of our mealy-back cockchafer, *Lepidoderma albohirtum* Waterh., were continued at intervals, and yielded additional information of an interesting nature. On the 4th and 5th instant numbers of trapped specimens were found to be much rubbed, having evidently been out for some

weeks, proving undoubtedly that the beetle in question remains susceptible to artificial light long after its emergence from the soil. It was necessary to settle this point once and for all, as in the event of its having transpired that such reaction was operative for a few hours only—viz., those immediately following emergence, as some entomologists have thought likely—the utility of this control method would have been seriously curtailed; whereas we now know that during favourable nights light is attractive to this beetle throughout its aerial existence. It is important to note in this connection that an interval of two weeks or more must elapse between the acts of emergence and egg-laying, and that the beetles do not as a rule all leave the ground on the same date. The early broods usually issue from ploughed land towards the end of November, appearing first in localities where the land is of a light character, and a week or so after on volcanic and heavy soils. Finally, an emergence may occur a little later from unploughed forest country. Thus it becomes apparent that the individual grower may be called upon to deal with two lots of adult females of *albohirtum* arising at different times from cultivated and forest lands, in which case the period preceding oviposition—the only profitable time for using light-traps—would necessarily be prolonged for a month or even eight weeks, dating from the first appearance of the beetles.

I am glad to be able to state that acetylene light appears to be equally attractive to both sexes of this insect. The proportion of females captured at light about the middle of last month (December) varied from 20 to 25 per cent.; but three weeks later, early in January, catches during two consecutive evenings yielded 47 and 75 per cent. of adult females. These differences were in accordance with expectations, as, although male specimens are known to predominate for a week or so after the first emergence, the sexes can generally be met with in about equal proportions by the beginning of January, and towards the end of that month previous conditions are often entirely reversed, and females become the more numerous.

Emergence of L. frenchi.

Two broods of our small reddish brown cane-beetle, *Lepidiota frenchi* Blackb., occurred this season, the insects appearing first about Christmas time and again late in January. (*See* p. 42.) On the latter occasion they emerged in countless thousands from forest country, grass paddocks, roadways, &c., and attracted considerable notice. Some idea of their excessive abundance may be gathered from the fact that on the 25th instant four collectors in half-an-hour picked off 23 lb. of these beetles from the fence of the Gordonvale Recreation Reserve in the centre of the township. It takes on an average 475 specimens to weigh 1 lb. (more than twice the number of *albohirtum*), so that the above-mentioned quantity represented no less than 10,925 beetles. Apparently this species prefers to oviposit in unbroken forest land, &c., rather than cultivations, although sometimes the grubs occur plentifully among cane-roots, and inflict serious damage.

It is well to bear in mind that a thick growth of weeds is likely to induce attack, and should on no account be allowed to occupy land intended for cane during the period when these beetles are engaged in ovipositing.

Poisoning the Beetles.

The question of controlling our principal cane-beetle, *Lepidoderma albohirtum*, by means of arsenical sprays applied to its various food-plants, is receiving attention at the laboratory, and results of preliminary experiments will be available for next month's report.

In the event of an effective spray being discovered, this method of coping with the pest may prove of practical value, as it would then be possible to protect a plantation of sugar-cane to an appreciable extent by poisoning the foliage of small feeding-trees reserved for such purpose in the immediate vicinity; and, if needs be, it might pay to plant clumps of the more favourite food-plants on headlands, as a permanent trap-crop. One often notices great quantities of the beetles on ornamental figs around homesteads in the centre of cultivations, when trees of this kind happen to occupy isolated positions.

An account of various experiments in this connection will be found in the following report for February:—

February 1915.

Experiments have been made at the laboratory recently to test the insecticidal effect of lead arsenate and other poisons on our greyback cane-beetles.

Specimens were placed in cylindrical cages of perforated zinc, fitting into flower-pots filled with moist sifted soil, and containing sprigs of eucalyptus leaves standing in water. By this method beetles from field collections lived in confinement for a longer period than any hitherto attained, the maximum duration in one instance being three weeks. The investigation took the form of a series of fourteen separate experiments, conducted in the usual manner with a varying number of cages, comprising those with treated foliage and untreated controls. Results may be briefly summarised as follows, figures referring to days to be taken in each case as being average numbers:—

Arsenate of lead 2 lb., mill molasses 1 lb., water 50 galls., proved fatal after 9 days, during which time 69 beetles devoured 32 square inches of poisoned leaves. A similar proportion of arsenate with the addition of ½-lb. of soap killed in 10½ days, the latter ingredient seemingly being less palatable than molasses, as, although in this case 62 beetles were employed, they consumed only 24 square inches during a longer period. Stronger arsenate-molasses solutions were found less effective, 3-50 and 4-50 strengths taking 10 days to kill, while the proportion of poisoned leafage devoured by the 52 beetles used amounted to about half that of shoots treated with the 2-50 1-molasses formula. Control specimens, 30 in all, feeding on unsprayed leaves, lived 14 days, and did not eat more food proportionately than beetles confined with poisoned foliage.

The above results are applicable to the latter half of the insect's aerial life, but may be considered as fairly conclusive. It is interesting to note that out of 276 beetles—part of the number used in this experiment—collected between 27th January and 8th February, 196 were females and 80 males.

Barium chloride, 2 per cent. solution (6 lb. in 30 galls. water) gave negative results, and apparently made foliage distasteful.

Other experiments started early in the month had to be discontinued about the 17th instant owing to a scarcity of beetles, due to the occurrence of abnormally hot weather from 4th to 15th February, when the average maximum shade temperature at the laboratory was 94·8 deg. dry heat and 87 deg. wet bulb. Under such trying conditions, control specimens, 40 in number, lived only 7 days instead of 14, and final results were rendered indecisive.

A few noteworthy conclusions, that will doubtless facilitate future research, may be deduced from the foregoing experimentation:—

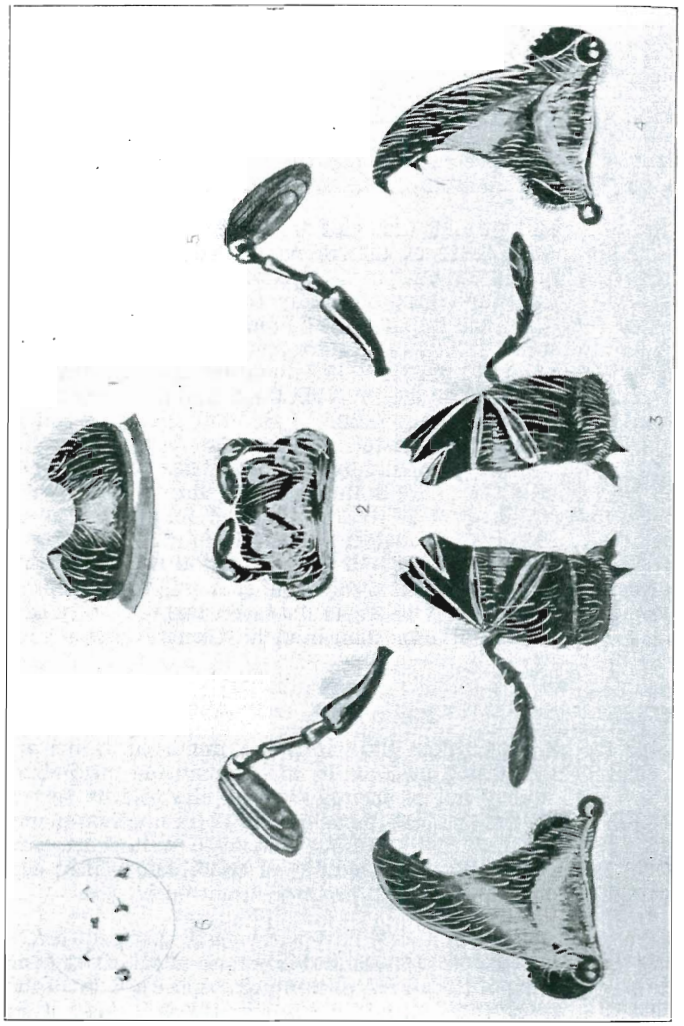
In the first place we find that this cane-beetle does not, like some insects, exhibit a keen sense of discrimination in the choice of food, but on the contrary appears comparatively indifferent as to its flavour, being as ready to devour leaves sprayed with poisons, molasses, &c., as untreated foliage. Such impartiality is not wholly surprising when one considers the insect's wide range of dietary, and that about thirty different food-plants have already been recorded by us, comprising eucalypts, acacias, figs, and a variety of shrubs, many possessing distinctive flavours. Secondly, we may conclude that lead arsenate, although slow in producing the desired effect, would probably be serviceable if applied to trap-trees, &c., immediately after the primary emergence of beetles in November, since under normal conditions food is partaken of directly after copulation, and oviposition does not follow until about a fortnight later. It might be worth while testing the action of this arsenical in the field, although further investigation may soon lead to the discovery of a more efficient spray, one that will kill in three or four days. It would certainly be advisable to resume the study of this important branch of control next summer, at the earliest date possible.

March 1915.

During the coming autumn and winter it is proposed to investigate some of the more promising methods of coping with the grub stage of cane-beetles, and it may not be out of place in the present report to introduce this side of the question to our growers, by briefly enumerating the various recognised control measures that may be brought to bear on such research work, and which, employed collectively, could hardly fail to produce beneficial results.

I have previously pointed out (p. 3) that ideal methods of combating this notorious insect are admittedly those in which we succeed best in preventing oviposition, by destroying as many egg-laden females as possible; but at the same time it would be as well to bear in mind that the greater length of the larval condition compensates to some extent for its being of secondary importance, since it enables us to practise control measures throughout a period of nearly six months, at a time when the sphere of action of this pest under the ground is greatly restricted, and it is subjected also to the injurious influences of various forms of climatic and natural control which do not affect the beetle state.

In the list given below I have attempted to arrange the principal preventive and remedial methods in numerical order of merit, determined by their relative claims to efficiency and practicability, although irrespectively of economic value at the present time. No. 3, for example,



MOUTH-PARTS AND ANTENNÆ OF GREYBACK COCKCHAFER.
(1) Labrum (upper lip). (2) Labium (lower lip),
(3) Maxillæ. (4) Mandibles.
(5) Antennæ. (6) Mouth parts, natural size.

is already extensively practised, and of considerable importance; but theoretically, No. 1, which is still in the experimental stage, must ultimately prove superior to No. 3, as under such ideal soil-treatment many cane-grubs would succumb a few days after hatching, and the remainder before being able to work appreciable damage. On the other hand grubs exposed to view while ploughing, pulling up stools, &c., represent but a small proportion of the number actually present in the soil, and moreover, being of fair size, have already injured the crop.

Control of Grub Stage.

A Few Remedial Methods.

(1) Incorporating with the whole of the soil, during ploughing or other cultural operations, some enduring substance (preferably cheap and non-poisonous) that shall prove quickly fatal to grubs, and at the same time possess manurial properties.

(2) The application to cane sets or planting furrows of an inexpensive deterrent, sufficiently obnoxious and durable to protect a limited area containing the main roots from invasion during most of the growing season.

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

(4) Applying insecticidal solutions to the main roots by pouring same into a trench against base of stools.

(5) Collecting grubs by hand whenever possible, both from behind the plough and under trash in wet weather.

(6) Working the soil at a time when grubs are lying near the surface, viz., a few days after rain; in order to expose them when possible to intense solar heat, and to attacks from insectivorous birds, &c.

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

(8) Maintaining the soil between young plants in a friable condition by frequent working, directly after first appearance of the beetles.

(9) Infecting the soil artificially with the Green Muscardine fungus or other parasitic diseases that may be found readily procurable and sufficiently effective.

(10) Promoting the protection of all indigenous grub-eating mammals and birds; together with the preservation, when feasible, of insect enemies of cane-beetles.

(11) The introduction into Queensland from other countries of special parasitic and predaceous insects known to attack cane-grubs closely related to our own species of Scarabæidæ.

Other methods of controlling the grub stage of cane-beetles could be mentioned, but those enumerated above will enable growers to realise the nature of operations likely to be serviceable when fighting the larval form of this pest.

While striving to attain ideal results from an application of such speculative remedies as Nos. 1, 2, and 6, we must not neglect the claims of more practical though commonplace control measures, some of which, in addition to being easily carried out, cost comparatively little, and are beneficial both from a cultural and an entomological standpoint. (*See* Nos. 5, 6, 7, 10.)

All influences affecting the economy of cane-grubs as a direct result of agricultural operations should be closely studied, the probability being that future developments in this connection may lead to issues of the first importance.

Results brought about by such factors, for instance, as the physical character of soils, cultivation, manuring, &c., are naturally influenced more or less by the weather, which tends to regulate the position and subterranean movements of grubs, thereby affecting indirectly the habits of their parasitic enemies.

A large percentage of cane-grubs perish annually as a necessary outcome of the controlling influence of various natural laws, designed to prevent their undue increase. Unfortunately the establishment of artificial conditions, and consequent destruction of the native flora over vast tracts of country, have interfered with the complex workings of these laws, with the result that our greyback beetle and other insects, being induced to substitute cultivated plants for their natural food, have gradually acquired a liking for the former, and become serious pests.

April 1915.

A New Fumigant for Cane-Grubs.

In November last a sample of para-dichlorobenzene was forwarded to us from the Sugar Bureau for experimental purposes.

The following details will illustrate some of the methods employed in this investigation:—As a preliminary test, six cane-grubs were confined in a closed cage holding 54 cubic inches of sifted soil, with which had been mixed 15 grains of the deterrent (1 oz. to 1 cubic foot). After two and a-half days all larvæ were dead and partially rotten.

This experiment was repeated on three subsequent occasions with similar results.

On 27th February, eighteen large grubs were placed in an open cage containing one cubic foot of unsifted soil, infected with half-an-ounce of coarsely crushed para-dichlorobenzene. Thirty-six hours later three had succumbed, and the remainder were lying motionless as though paralysed; all dying in less than a fortnight.

Tests were then applied to determine the effect on larvæ of isolated injections of the chemical in crushed form, administered at various depths; and these trials proving satisfactory it was decided to experiment in the open.

A plot of red volcanic land was accordingly dug 9 inches deep, a row of four months' old cane-stools planted, and on 5th March the land treated with a series of ¼-oz. injections, inserted 1 foot apart in a straight line on each side of stools, 6 inches from same and 7 inches in depth. About 50 grubs were then placed a couple of inches below the surface, above injections, and the ground left undisturbed for a fortnight. At the expiration of that period a faint odour of para-dichlorobenzene was perceivable in the soil at a distance of 15 inches from injections, and strongly impregnating to the full depth of the digging a strip of land 2 feet wide. Examination revealed the presence of a few dead grubs, the living ones having apparently been driven from the infected area. The cane plants continued perfectly normal, and were rooting freely.

With view to determining the action of this chemical on larvæ compelled to remain under its influence, a plot of ground was prepared on 3rd April by being dug 9 inches deep, allowed to settle for a few days, and treated with a single line of ¼-oz. injections placed 1 foot apart and 5 inches beneath the surface. Grubs of the greyback cane-beetle were then buried in the soil at various distances from the chemical,

each larva being confined in a specially designed cage of perforated zinc filled with soil, that while preventing extended movement in a horizontal direction allow it to descend vertically to a depth of 9 inches, or ascend to within an inch of the surface; and at the same time ensured continuous natural conditions with respect to drainage, moisture, temperature, &c.

Examined on the 12th instant (9 days later) the entire soil was found more or less impregnated with the odour of the deterrent, to a distance of 1 foot on each side of injections. Larvæ placed at distances of 6 and 8 inches were dead and discoloured, those at 9 inches dying but able to move convulsively, and those a foot away alive and apparently healthy. Grubs situated 9 inches from the chemical succumbed on the 18th instant (after 15 days), while those at a distance of 1 foot, and control specimens, continued unaffected throughout the experiment. This test was repeated later with practically identical results; and further trials, in which the injections were reduced to 80 grains placed 1 foot 6 inches apart, also proved satisfactory.

With reference to the rate of evaporation of para-dichlorobenzene, I observed that in dry weather ¼-oz., after being 15 days underground at a depth of 7 inches, subjected to an average temperature of 69 deg. F., weighed 3 scruples 5 grains, thus indicating a loss of nearly 50 per cent., but did not actually disappear until the end of six weeks. Better results could probably be obtained from injections made of a single lump like a "moth-ball," as in this form the same amount of chemical might last two months or longer, while its application would be simplified. Under wet conditions both evaporation and soil-infection were retarded.

It is worth noting that the deterrent odour remains in the ground long after complete evaporation of the fumigant. Soil under cane-stools treated 5th March was still strongly infected on the 8th May, three weeks after the chemical had disappeared; from which we may assume that a limited area of such contaminated soil—comprising, say, a strip at least 1 foot wide—would continue to be repellent until the odour became less decided.

Para-dichlorobenzene is sold in the form of irregularly shaped crystalline nodules, possessing a somewhat pungent but not unpleasant odour, not unlike that of benzine, and differs from naphthalene in being semi-transparent, duller in colour, and not flaked.

The price before the war was stated to be about 6d. a pound, and at this rate it would cost 30s. to treat an acre with injections of 80 grains, placed 18 inches apart under each row of cane; or 44s. for the same number of ¼-oz. injections.

Para-dichlorobenzene should also prove serviceable as a repellent against oviposition, it being exceedingly improbable that our greyback cane-beetle would either enter or deposit eggs in soil contaminated with an odour fatal to its offspring. This question is likely to prove of exceptional interest later on.

May 1915.

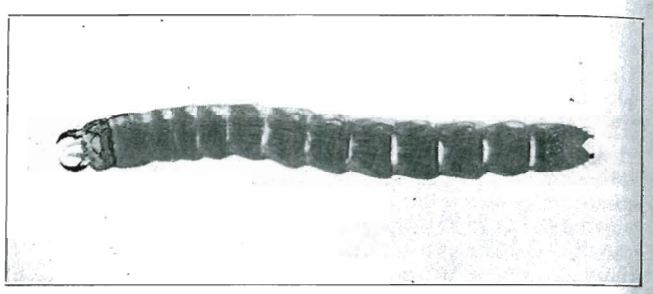
Collection of Insect Pests of Cane.

I wish to state that a number of pinned and mounted specimens of insect pests associated with sugar-cane have been collected by us during the past nine months, comprising 1,056 specimens, representing 425 distinct species. Forty-nine of these are more or less injurious to cane,

and 34 beneficial, while the remainder comprise miscellaneous species either closely related to the foregoing or incidentally associated with them. The work of rearing and studying the life-history of Scarabæidæ affecting cane is being continued, and experiments have been commenced with a view to acquiring information respecting parasitism in this connection.

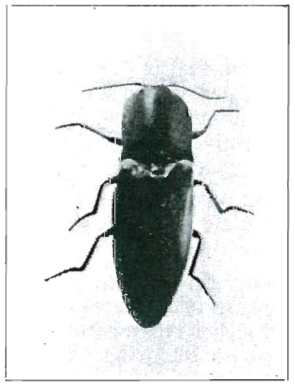
Elaterid Larva Attacking Grubs.

Referring to the question of Useful Insects—a matter not hitherto dealt with in these reports—I may mention that the larval form of an eminently predaceous beetle (*Agrypnus mastersi* Pasc.) has been under continuous observation at the laboratory since November last.



PREDACEOUS LARVA OF ELATERID BEETLE (NAT. SIZE).
Photo., W. C. Dormer.

This elaterid is extremely voracious, attacking both larval and adult forms of our cane-beetles. It occurs sparingly in volcanic and sandy soils around Gordonvale, and in general appearance is not unlike a very large but flattened "wire-worm," with highly polished dark yellowish-brown body, and formidable sickle-shaped jaws. A specimen collected on 6th November, 1914, killed and devoured no less than 126 large cane-grubs and 4 greyback beetles during a period of seven months, and is still (4th June) in the larval stage, and as greedy as ever.



ELATERID BEETLE (NAT. SIZE).
Photo., W. C. Dormer.

When first caught it measured about 2¾ inches in length, so had doubtless previously accounted for numerous grubs, as growth during confinement has been slow, and in spite of so liberal an allowance of food the larva has grown only one inch in seven months.

Additional smaller specimens were collected on 16th November, 1914, and up to the present two of these have between them killed and consumed 206 cane-grubs and a few beetles.

I was fortunate in observing one in the act of eating a cane-beetle that had been placed in its breeding-cage. About one-third of the "wire-worm" was buried out of sight in the body of its unfortunate victim, whose neck had been severed to enable the elaterid to push its head through the thorax into the abdomen for the purpose of imbibing the succulent contents.

The record of mortality mentioned above was attained by larvæ confined at close quarters with their prey, in cages holding 54 cubic inches of soil. Under normal conditions, however, they would be compelled to hunt for grubs by tunnelling through the ground, and might at times have to travel several feet before locating one; so that normally the percentage of grubs destroyed would necessarily be lower than that obtained in the laboratory, and would also vary in different districts according to degrees of infestation. In localities like Greenhills, where soil conditions are congenial and grubs frequently occur in excessive numbers, this predator should be very much at home, and able to do great execution. Apart from economic considerations, the breeding of this beetle and study of its life-cycle will prove of scientific interest.

Mr. R. Illidge, of Brisbane, a well-known entomologist and authority on the habits of our Queensland Elateridæ, informs me that four of our large arboreal species, belonging to genus *Alaus*, are predatory on various large wood-boring beetles (Cerambycidæ). He has frequently observed larvæ of *Alaus gigas* inhabiting tunnels of its host (*Batocera* sp.) and attacking grubs, pupæ, and even newly emerged imagos of this beetle.

It may be mentioned, too, that a predaceous elaterid (*Pyrophorus luminosus*) is known to destroy grubs of May beetles (*Lachnosterna*) in the canefields of Porto Rico.

June 1915.

New Light-Trap for Cane-Beetles.

As a result of certain field experiments conducted during November and December last, acetylene light was proved to be very attractive to both sexes of our principal cane-beetle throughout its aerial existence, such reaction, however, being considerably influenced by various meteorological and other conditions. The movements of the beetles while flying near artificial light were studied, particularly their manner of approaching the trap and behaviour when within a foot or so of the flame; and certain conclusions arrived at regarding the kind of design most likely to produce a serviceable light-trap, and the conditions under which it might be expected to yield payable results.

As an outcome of these observations an entirely new form of light-trap will be constructed for trial during the coming season.

Such contrivances usually aim at capturing the insects simply by means of a shallow tray or pan containing water covered with a film of kerosene and placed under a strong light. This method, however, is not to be commended in the present instance, for the following reasons:—

Firstly, it entails extra labour and expense, which although small would nevertheless be a consideration when dealing with a number of traps. Secondly, it would destroy a certain proportion of useful insects, both parasitic and predaceous, which help to control not only the cane-beetle in question but a number of other insect pests of sugar-cane. In this connection I may mention that a well-known enemy of cane-grubs (*Campsomeris tasmaniensis* Sauss., the common "Digger-wasp"), and probably a beneficial cockroach (*Ellipsidion pellucidus* Brunn) which frequents foliage of sugar-cane, are attracted to artificial light. An

arboreal species of earwig also, which I believe to be predaceous on small lepidopterous larvæ of at least one of our cane-pests, flies to light in great numbers.

Lepidoderma albohirtum responds to the stimulus induced by acetylene light from a considerable distance. It rarely flies directly into the flame, but when within a few yards approaches in an erratic manner by a series of short flights, settling at brief intervals on the ground or on cane-plants, and finally, as though struggling against the phototropic influence, plunging headlong downwards at a distance of about a foot or eighteen inches from the light. Our new trap will be fitted with a landing stage designed to take advantage of the above habit and immediately capture all beetles that may settle or fall upon it. Suitable exits, however, will be provided for useful insects, as predaceous ground-beetles (Carabidæ), and the various hymenopterous parasites. The glass screening the flame will be inclined at an angle calculated to throw beetles dashing against it into the trap.

Controlling Grubs, &c.

Recent experiments in connection with control of the grub form of *albohirtum* have, for the most part, given negative results, but, although in a measure disappointing, such work in reality serves a useful purpose by directing investigation into other channels, which during the gradual process of contraction must eventually come to a focus somewhere, and in all probability reveal a pathway to ultimate success.

Whilst stationed at Gordonvale I have sought to embrace present opportunities for studying the life-history of all insects found affecting cane, the majority of which, although of minor importance, include a few decidedly injurious species and several hitherto undescribed forms. Such knowledge is, of course, essential to a comprehensive survey of the cane-grub problem, since methods of control proving effective against one kind of pest may eventually be found to destroy certain natural enemies of some other and perhaps more serious cane-insect.

July 1915.

Methods of Fighting the Greyback.

Arrangements are being made to conduct a few initial experiments in connection with oviposition, and to resume research work commenced last season relating to control of the adult beetles.

The period immediately following the primary emergence, and lasting about a month, is naturally of great economic importance, embracing as it does both the egg and imago stages, and therefore affording possibilities of getting at the root of the trouble by preventing deposition of the eggs, or destroying them before they hatch.

It is hoped that these experiments will to some extent test the value of the following remedial methods applicable to the beetle and egg stages:—

(1) Trapping beetles by means of artificial light;
(2) Trapping beetles by the use of attractive odours;
(3) Preventing oviposition by poisoning the female beetles;
(4) Preventing oviposition by means of deterrents applied to the surface of the ground, or fumigants injected into the soil close to cane-stools.

Preliminary trials respecting No. 2 were started last November, but I have not hitherto alluded to these experiments, although of opinion that such work may prove of great value and well worth following up.

This field of research is especially fascinating from a scientific standpoint, seeing that it calls for a knowledge not only of entomology but of biochemistry, physics, &c., &c. Such a subject is of course too complex to admit of anything like full discussion in a monthly report, but I may mention that results are entirely dependent on certain influences arising from the operation of various natural laws governing the movements of insects. For instance, we find that artificial light, whilst repellent to some species, is more or less attractive to others.

The moth or beetle that flies into the flame of a lamp must not be held accountable for such action, as it is merely responding to influences over which it has no control. Similarly, decaying animal matter emits an odour which compels blowflies and other insects to approach and settle on it, and while under such domination to deposit eggs, that later on will produce maggots destined to serve a useful purpose in the economy of nature. We may therefore reasonably assume that the movements of our mealy-back cane-beetle are governed by forces that probably exercise important influences on the flight of the adult female prior to oviposition.

Cane-growers might render valuable assistance in this connection if they would occasionally watch the beetles whilst swarming at dusk, and in the event of noticing abnormal numbers congregating on the ground either close to the house or in the field, as though attracted to a particular spot or portion of land, &c., communicate at once with the entomologist.

Methods 1 and 3 have already received a little attention, and appear worthy of future investigation.

August 1915.

Influence of Weather on Cane-Beetles.

The present season is unusually interesting owing to a continuance of dry weather, and consequent establishment of abnormal climatic conditions which are certain to have an effect on the economy of soil-frequenting insects.

In a previous report (*see* pp. 4-5) when alluding to what I have termed Meteorological Control, it was mentioned that, during September and October 1914, larvæ of *albohirtum* had pupated unusually near the surface, large numbers having been ploughed up on volcanic soils.

This exceptional circumstance was probably due to the abundant rainfall experienced at Gordonvale during August 1914, thirteen days of which were wet, the registered precipitation having exceeded the average for that month by 3·45 inches. It has already been pointed out that excessive wet about that time of year tends to induce grubs to pupate near the surface; and, should hot weather set in shortly after pupation and continue for a month or so, great numbers of pupæ lying in light volcanic and sandy soils under seed-cane would be likely to perish, owing to the earth overhead becoming dry and hard before they were able to transform into beetles. Unfortunately, as foretold in a previous monthly report (*see* "Australian Sugar Journal," vol. vi., p. 629), further rains about the end of October 1914 put an end to our hopes in

this direction, by maintaining ideal soil conditions for the development of cane-beetles. To the occurrence of this later rain must, I think, be attributed in great measure the severity of the recent outbreak at Greenhills, where no less than 25 tons 11 cwt. of grubs were collected during March, April, and May, 1915, at a cost of £748 sterling.

This serious monetary loss might have been very considerably reduced had the dry weather continued throughout October 1914.

With regard to the present season, no rain fell at Gordonvale last month (July), and, as an outcome of prolonged dry weather, grubs infesting light soils started to pupate about the middle of August, three weeks earlier than last year. Wishing to find out the position of pupæ of *albohirtum*, tests were applied on the 3rd instant to a plot of affected land, by digging a number of pits 5 feet square by 2 feet deep at varying distances apart. The first four holes contained collectively 23 pupæ, 4 larvæ, and 1 beetle of this species, besides 32 grubs of other Scarabæidæ (principally *Lepidiota frenchi* Blackb.), in various stages of growth. No pupæ were unearthed nearer than 1 foot from the surface, and none deeper than about 15 inches. The majority were lying in earth nearly dry. A month later further tests were made on the same piece of land, when it was found that the soil had become still drier, and fully 20 per cent. of the pupæ perished; while the remainder had transformed into beetles which were resting in the pupal chambers awaiting the arrival of rain sufficiently heavy to soften the ground and enable them to escape to the surface.

Should the present weather conditions continue, it will be interesting to note the effect of drought on these adult insects imprisoned in their subterranean cells.

September 1915.

Control of Grub Stage.

Studies relating to the control of our common cane-beetle *Lepidoderma albohirtum* during its grub stage are being continued, experimentation having for the most part been confined to the trial of various poison baits. This interesting branch of research will be carried on as long as possible, but the majority of larvæ will soon be pupating, and in some districts have already gone down out of reach of the plough.

Australian Sugar Producers' Association at Mossman.

Towards the end of July I attended a conference of the Australian Sugar Producers' Association at Mossman, and read a paper embodying an account of the various activities of this Experiment Station during the past ten months.

The reading of this review was followed by discussion, when, speaking of predaceous insects, I pointed out that action in this direction, viz. propagation and distribution, was not always advisable in the case of indigenous species, owing to the repressive influence exercised by their hyperparasitic and other foes.

Knowledge of this fact, however, need not cause us to wholly neglect the utilisation of Australian parasitic or predaceous species, or regard such methods as being invariably beyond our control. It is not unreasonable to assume that in a vast territory like Queensland, supporting thousands of useful insects inhabiting widely separated districts, we

might be able in some cases to derive assistance from an introduction of useful native species of local occurrence, provided they were transferred from considerable distances, and without their hyperparasitic and other natural enemies.

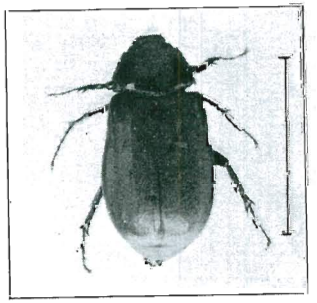
As an instance in point it may be mentioned that a chalcid parasite (*Nasonia brevicornis*) of our formidable sheep-maggot fly (*Calliphora rufifacies*), discovered by the writer in Central Queensland, 10th October, 1913, is at present being extensively bred at the Brewarrina laboratory, New South Wales, and has already been distributed to many of the fly-infested sheep stations, being considered to be an important factor in reducing the numbers of these destructive blowflies.

Allusion was also made at Mossman to the matter of proposed importation from other countries of such useful insects as digger-wasps, which are known to be enemies of Scarabæidæ closely related to our own cane-beetles. Other matters were brought up, one of which referred to the apparent scarcity of grubs in certain districts from causes unknown. We hope to find time to investigate cases of this kind, which may afford some clue of decided value. In some instances, however, such immunity may reasonably be attributed to unsuitability of the soil, or absence of food-plants of the beetle in the vicinity of plantations, or possibly to a natural non-occurrence of the pest, due to adverse climatic influences.

October 1915.

Emergence of Beetles at Babinda.

On the 8th instant 2¼ inches of rain fell over the Babinda area, and the following evening cane-beetles were reported to have appeared in enormous numbers, justifying previous conclusions as to the probability of emergence being exceptionally early this season, on account of the drought.



Lepidiota caudata Blackb.
Photo., W. C. Dormer.

At Deeral and McDonnell's Creek three species were in evidence, the most plentiful being *Lepidiota caudata* Blackb., a dark reddish-brown beetle, slightly smaller than the greyback but considerably larger than *L. frenchi*. It probably breeds extensively in scrub lands, where it is said to do as much if not more damage to cane than the notorious greyback cockchafer. Its near relationship to the latter species, prolificness, together with the large size and voracity of its grub, all point to the possibility of *caudata* becoming a serious cane-pest. It is proposed to make a special study of the larval condition of this beetle during the coming season.

Another insect associated with *caudata* at Deeral was *Anoplognathus punctulatus* Oll., a dark, shining, golden-green species, allied to our so-called "Christmas Beetle," but much smaller. Although adults have been previously noticed in canefields, the grubs of this beautiful insect have never been found under stools eating the roots, so that *punctulatus*

cannot at present be justly included in our list of Scarabæidæ attacking sugar-cane, and is not, in my opinion, likely to become troublesome in the future.

At Gordonvale, weather conditions are unchanged, little or no rain having fallen here during this month (October).

Despite abnormal dryness, however, beetles that transformed about the middle of September have managed to keep alive for over six weeks, and are still lying in their pupal chambers at a depth of 9 to 12 inches below the surface. Unless heavy rain softens the soil before the end of November a large percentage of these beetles may perish, while those able to emerge, being much weakened, may lay fewer eggs than usual.

November 1915.

Flight of Cane-Beetle Influenced by Topographical Conditions.

An inch of rain was recorded by the Mulgrave Mill during this month, the fall varying in different localities but being insufficient to establish soil conditions suitable for a general emergence of greyback beetles. Two root-eating Scarabæidæ of minor economic importance, belonging to the genera *Dasgynathus* and *Anomala,* appeared in canefields about the 15th instant.

It has been deemed advisable to commence a study of the topography of Gordonvale, in order to determine as far as possible the relation of topographical conditions to influences exercised by various forms of agricultural and natural control. The importance of this branch of research cannot be over-estimated, since it affords a means whereby we may arrive at a feasible solution of such questions as the following:—

(1) Why did our greyback cane-beetle attack sugar-cane in the first instance?

(2) Why do certain localities, as Greenhills, &c., remain seriously grub-infested, while others are either unaffected or comparatively free from attack?

(3) Why are canefields in certain limited areas quite free from grubs, but adjoining plantations either permanently affected, or liable to gross infestation for a few seasons, followed by long intervals of freedom from the pest?

A detailed account of observations in this connection will form matter for special report later on; but it may not be out of place at present to allude very briefly to a few significant phases of the question. Referring for example to the destruction of feeding-trees as a means of repression against the adult beetle, the success of this procedure depends to a very great extent on such factors as the geographical position of an affected area, its surrounding geological conditions, and the character, disposition, and relative abundance of timber in the vicinity. This being so it follows that, although of importance as a practical remedy, an indiscriminate cutting down of all trees, even though including food-plants of the beetle, would not prove beneficial in every case. Such action indeed, instead of affording relief, may in some instances even tend to aggravate the evil.

I am indebted to the courtesy of the manager of the Mulgrave Mill and various growers in the district for information respecting degrees of infestation in different canefields, and other details of a more or less helpful nature.

Effect of Dry Weather on Beetles in Pupal Cells.

An interesting circumstance regarding the effect of drought conditions on cane-beetles unable to tunnel through dry ground has just been brought under my notice. It appears that while preparing volcanic soil for cane-planting at Carrah Estate, Meringa, about the 28th instant, dozens of dead greyback cockchafers were turned up in the drills, no living ones being observed. The depth of ploughing on this occasion was one foot, in ground fairly loose near the surface but very dry. As previously reported (page), pupæ of this species assumed the adult or imago form about the middle of September; from which we may infer that in certain soils this beetle is probably unable to remain alive underground during dry weather longer than about ten weeks.

Further details in connection with this matter are reserved for my next report.

December 1915.

From one to two inches of rain fell at Gordonvale this month, between 11th and 12th instant, and was at once followed by a primary emergence on volcanic soils at Meringa of the cane-beetles *Lepidoderma albohirtum* and *Lepidiota frenchi.* The former was fairly abundant at Carrah Estate, but had the season been a normal one would probably have appeared in greater numbers. Unfortunately the most favourable time for experimentation with light-traps, viz., throughout the week immediately following emergence of beetles from the soil, happened to be moonlight; so it was decided to experiment during this period with various bait-traps in hopes of discovering one that might prove attractive to the adult insect.

Experiments with Aromas.

Eighteen different odours were tested, both alone and in combination, including oils obtained from plants closely related to those upon which *albohirtum* is known to subsist; but no definite positive reaction was noticed. We must not, however, expect speedy results from this method of control; in fact, the possibilities of its ultimate success are somewhat uncertain.

Had our enemy been a moth or dipteron (two-winged fly) the task would perhaps have been simplified, as many such insects are very susceptible to odours emanating from vegetable and mineral oils.

The cane-beetle in question is a sleepy sort of creature at the best of times, its motions even when on the wing being lumbering and ill-directed. Moreover, its wide and varied range of dietary tends to curtail the chances of our being able to induce reaction towards aromas resembling those associated with the food-plants of this pest. Experiments just made at our laboratory, however, have demonstrated the susceptibility of *albohirtum* to various aromas. Details need not be given here, but I may mention that the beetles reacted very noticeably and at once to the odours of cajeput oil, acetic acid, carbolic, and nitrobenzine, but were most strongly affected by oil of almonds. They were not in the least influenced by such substances as oil of cloves, fish oil, or even the pungent fumes of formalin 40 per cent. strength. Knowledge of the above facts justifies us in assuming that reaction of a positive nature is, at any rate, within the bounds of possibility, and should encourage further research in this connection.

Discovery of an attractive substance would, I feel sure, go a long way towards solving the cane-grub problem. Once succeed in luring the beetles to a given spot and their capture by mechanical methods would prove a simple matter. This method of repression is being successfully practised in parts of Europe, where bait-traps are extensively used against a formidable vine-moth (*Clysia ambiguella*). At a vineyard in France, for instance, during 1913, some of the catches per acre were from 1,200 to 2,400 of these moths, the greater number being females each capable of laying from 120 to 170 eggs.

The aerial movements of our cane-beetles are certainly influenced very sensibly by (1) topographical conditions, (2) the presence and position of feeding-trees, and (3) the mechanical nature of soils.

Interesting Instance of Climatic Control.

A noteworthy instance of direct natural control brought about by hot weather occurred towards the end of this month. On the 19th instant we experienced a maximum shade temperature of 95 deg. F. followed next day by 98 deg. F., the wind being from the warm quarter (north-west).

During the morning of the latter day cane-beetles (*L. albohirtum*) became strangely agitated, and instead of remaining as usual on their food-plants were observed by my assistant, Mr. A. P. Dodd, to be taking short erratic flights and congregating on the shady side of tree-trunks, apparently trying to discover some cool resting-place. Later, in the afternoon, a party of blacks at Meringa told the manager of Carrah Estate that large numbers of cane-beetles were dying and dropping from the trees. Finding their account to be correct, Mr. Greenaway communicated with this office, and the matter received personal investigation. Upon reaching the locality in question the ground was seen to be strewn with dead greyback beetles, mostly under or in the vicinity of Moreton Bay ash trees (*Eucalyptus tesselaris*). No less than 25 were collected from beneath one gum-tree of medium size, and in a space containing two square chains, taken at random on forest land, 98 were picked up. Of these 27 were males, 49 females, and the remainder of indeterminate sex owing to their having been partly eaten by ants. The above area was hastily examined, so no doubt we overlooked many specimens hidden among herbage, &c.

The occurrence of such heavy mortality is very interesting from the fact of its having happened about seven days after emergence of these beetles, and consequently before they had had time to oviposit.

I dissected several, and in all specimens examined found the ovaries only partially developed. Two beetles contained 27 eggs each, most of which were more than half-grown.

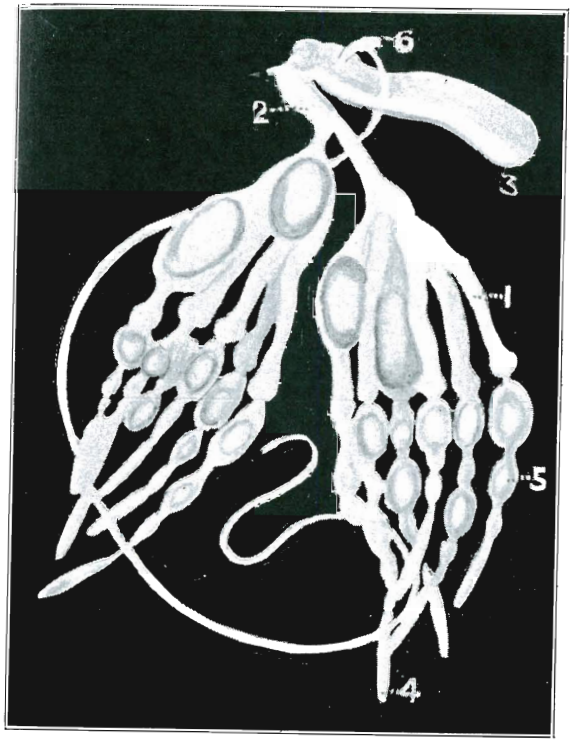
Egg Stage of Greyback Cockchafer.

January 1916.

Field investigations in connection with the oviposition of our greyback cane-beetle proved disappointing, a single batch of eggs having been unearthed by Mr. A. P. Dodd, as a result of examination of about 150 cubic feet of ground. These eggs to the number of 15 were deposited loosely at a depth of 5 inches, and almost directly under the centre of a stool of ratoon cane. It was hoped to have secured sufficient evidence to warrant the publication of recommendations regarding control of

this stage by the practice of certain cultural methods. Such advice, however, will need to be postponed until next season, when we expect to obtain conclusive data on this important matter.

Breeding experiments for the purpose of determining the number of eggs laid at the one time, and whether a beetle deposits more than a single batch, yielded evidence of a somewhat indefinite nature, the numbers laid by different individuals varying from 10 to 26.



OVARIES OF "GREYBACK."

1. Ovarian tube.
2. Oviduct.
3. Copulatory pouch.
4. Terminal chamber.
5. Immature egg.
6. Spermatheca.

E. Jarvis, del. original.

As a result of numerous dissections I am inclined to believe, from the structure of the ovary, that most of the eggs usually mature simultaneously, and are deposited in one large batch of 24, after which, under normal conditions, a few additional eggs may be laid loosely in the soil either singly or in small batches of three or more. The two ovaries together comprise twelve ovarian tubes (fig. 1), each holding 3 eggs, 2 of which, as already mentioned, develop first, while the other 12 farthest from the oviducts continue quite small. After deposition of the main batch of 24 these others may develop, some days later.

Examination of the ovary of a beetle which died in confinement after laying 26 eggs revealed the presence of an additional 9 in different stages of growth. Under natural conditions some, or perchance all, of these might have found their way into the soil before death of the female.

About 350 young larvæ were hatched from eggs laid by greyback beetles confined at the laboratory during December and January, and will be used in future experiments relating to control of the grub stage of this pest.

Effect of Larvicides on Cane-Grubs.

February 1916.

Research work regarding control of the grub stage of our cane-beetle is now in hand. A number of experiments in this connection were carried out last season, but being of a preliminary nature were not reported.

The study of larvicides has been continued, as, although this form of control is of secondary importance, there are times when limited areas of grossly infested soil may be profitably treated with insecticidal solutions. The following chemicals were found to exhibit larvicidal effects worth mentioning:—

(1) Creolin (1 pint in 50 galls. water), applied to grubs in cages of soil at the laboratory, proved fatal to 100 per cent. Its action was rapid, larvæ being found partially decomposed 24 hours after treatment. The price, however, is prohibitive, since it would cost about one penny to treat four stools, using 2½ galls. of solution per stool. Five quarts (1-50 formula) were applied to the roots of a single stool without injuriously affecting the foliage.

(2) Cyanide of potassium (1 lb. in 200 galls. water) destroyed 100 per cent. of larvæ in cages of soil, and also in the open, when applied to the roots of a stool under which a dozen grubs had been placed a few hours before treatment. A plant 2 feet high watered with 8 quarts of this solution showed slight signs of wilting after 24 hours, but regained its normal appearance a week or so later. The Mamelle method of applying cyanide by injection was tested in a preliminary way with satisfactory results. In one of these tests 20 grubs were placed a few inches apart in a trench 4 to 5 inches deep around a flourishing stool of plant cane, and the earth replaced but not watered. On the following day two ½-oz. injections, of a solution prepared by dissolving 7 oz. potass. cyanide in one quart of water, were administered on each side of the stool, nearly under the centre of same. When examined 5 days later 2 living and 13 dead grubs were found within a radius of 9 inches from centre of stool—the former imbedded in hard subsoil below the level of injections, and four living specimens at a distance of 1 foot from the plant. The injected solution was still decomposing, and diffused a strong odour of potass. cyanide. The above experiment was made last year, but fuller investigations were postponed in view of the high price of this chemical. I may mention that the Mamelle process was first made known to our growers by Mr. Tryon in 1910 ("Australian Sugar Journal," vol. ii., p. 88): "This treatment," he writes, "allowing for about 50 cubic centimetres per plant, would work out at about 40 lb. of potassium cyanide per acre. And in estimating the cost a set-off must be made on account of the value as a fertiliser of the potash added to the soil through the procedure."

(3) Borax (1 lb. in 3 galls. water) proved efficient, but too expensive for general purposes.

(4) Creosote (8 oz. to 5 galls. water) emulsified with "Sunlight" soap gave fair results.

Control larvæ in all of the foregoing experiments remained normal throughout.

Solutions of the following chemicals applied to soil in cages had no perceptible effect on larvæ of the greyback beetle:—Saltpetre (1 lb. to 3 galls. water); barium chloride (1 lb. to 3 galls. water); hellebore (1 lb. to 12 galls. water). These negative results are somewhat remarkable, since both saltpetre and hellebore are known to possess decided larvicidal properties.

Experimentation regarding control of the grub stage by means of stomach poisons was commenced about the 12th instant. Initial work in this connection during last season (not yet published) has served to direct present research into promising channels, and I may say that this branch of control appears to be progressing favourably.

March 1916.

This month has been devoted almost exclusively to the study of an important branch of control applicable to the grub stage of cane-beetles, which aims at the discovery of some simple yet effective method of destroying them while in their earlier stages.

It is satisfactory to be able to state that experiments conducted during February and those now in hand have been attended with marked success, and I hope very shortly to be in a position to report details of a discovery that may be of value.

New Moth-Pest of Cane.

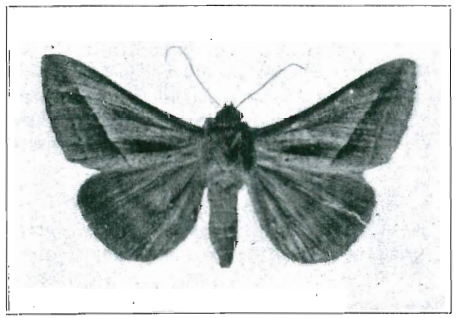
It will be of interest to mention the occurrence at Meringa and Gordonvale of a new moth-pest of sugar-cane hitherto unrecorded.

Early this month thousands of slender greenish-brown caterpillars were noticed stripping the leaves of both young and old stools, often to the midrib, over areas of considerable extent. This damage was confined principally to plantations on which weeds had been allowed to mature, these having no doubt served to attract the moths in the first instance. Apparently the caterpillars had quickly forsaken native food-plants, and turned their attention to cane-leaves, as being perhaps more palatable than the foliage of smaller grasses, &c.

A number were collected for breeding at the laboratory, and in due time pupated on the leaves, the pupa being concealed in a short tube previously constructed by the caterpillar by webbing together opposite edges of a leaf-blade. Contrary to expectations, very few were parasitised, fully 90 per cent. yielding moths, and the remainder specimens of a tachinid fly, but no hymenopterous parasites.

The perfect insect, which measures about 1½ inches across the expanded wings, is slaty brown with a darker stripe bordered by light grey—very conspicuous in the male—running obliquely from apex to hind margin of fore-wings, and has two suffused smoky bands crossing the centre of hind-wings, parallel to the outer margin, that nearest the edge terminating in a dark blotch on the upper angle.

Dr. A. J. Turner, of Brisbane, who has identified this insect as *Mocis frugalis* Fab., tells me it is a widely distributed species, ranging from Port Darwin to Sydney, and occurring also in many other parts of the world. Its presence at Gordonvale in such numbers may, I think, be attributed to the recent drought, which has temporarily upset the balance of nature, thereby affecting the normal rate of increase of many kinds of parasitic and predaceous insects. The familiar little ant, for example, *Pheidole megacephala*, has received a severe check this year in certain localities near Gordonvale. During the earlier months of last year it proved a veritable pest at the laboratory, necessitating the use everywhere of ant-proof tables; while outside among blady grass it swarmed



Mocis frugalis Fab. (1½ times nat. size).
Photo., W. C. Dormer.

literally in millions, scarcely a square yard of ground remaining uninfested. It occurred more or less freely too in canefields, where, by devouring injurious caterpillars, &c., it probably helps to thin the ranks of more than one of our many enemies of sugar-cane. Few insects escape the attention of this voracious ant, which systematically explores every plant, hole, and crevice in search of prey. Since the drought, however, not an ant is to be found about the laboratory buildings, and they seem to have practically disappeared from soil under cultivation.

April 1916.

Preliminary experiments with poison baits for cane-grubs (not yet reported) were initiated in 1915, but need not be mentioned here; it having been decided by the General Superintendent of Bureau of Sugar Experiment Stations to issue, almost at once, a bulletin dealing with recent discoveries in this connection, which will embody also a brief survey of early investigations.

NOTES ON GREEN MUSCARDINE FUNGUS.

During this month (April) 7 inches of rain was recorded by Mulgrave Central Mill, as against 3·44 inches for the Cairns district during April 1915. Practically the whole amount fell here between the 27th instant and 4th May, the mean temperature during this period of eight days being approximately 77·25 deg. F. accompanied by an average humidity of 73 deg. F.

The above record acquires scientific interest from the fact that these climatic conditions are evidently favourable to the development of the so-called "Green Muscardine" fungus (*Metarrhizium anisopliæ* (Metsch.) Sor.), an outbreak of which in volcanic soil near Meringa was brought under my notice on 3rd May. Upon inquiry I found that the mortality occasioned, although sufficiently marked to have aroused the curiosity of those engaged in collecting grubs, was not excessive, and that the fungus was attacking full-grown larvæ of *Lepidoderma albohirtum* Waterh.

Most growers are familiar with the appearance of grubs killed by this vegetable parasite, as the body, instead of decomposing, retains its shape, and, gradually hardening, turns at first whitish and finally dull green. The internal organs and fluids of the victim are quickly absorbed, and replaced by vegetable tissue constituting the mycelium or rooting portion of the fungus, until the entire grub becomes as firm as a piece of hard cheese and can be easily broken into pieces.

As already pointed out in previous reports, it might be found advantageous to artificially disseminate this entomogenous parasite over grub-stricken areas. Investigations in this direction have hitherto been confined almost exclusively to cage experiments dealing with methods of inoculation, &c., but, owing to work of a more pressing nature supervening, were discontinued some months ago.

For the present I should advise cane-growers to see that all grubs harbouring this fungus are left in the ground, or, better still, broken into powder, thoroughly mixed with plenty of finely sifted soil, and sown as thinly as possible in furrows when planting or ploughing up old areas of grub-infested ground.

May 1916.

COLLECTING CANE-GRUBS.

Grubs of the common cane-beetle *albohirtum* will soon be going down out of reach of the plough preparatory to pupating, all specimens collected at the laboratory during the present month having been third-stage larvæ, and for the most part fully developed.

Considerable damage has been occasioned by this insect in the Highleigh and Babinda areas, and at Greenhills it is credited with destroying about 300 acres of cane.

It appears, from information supplied by the secretary, that grubs received at Mulgrave Central Mill during 1916 season were mostly from Greenhills, Mount Sophia, and Meringa.

Mr. L. O. Bailey, Secretary of Babinda Cane Growers' Association, advises that receivers in his locality have weighed in about 24 cwt. of grubs, most of which were collected in the vicinity of McDonnell's Creek.

In a previous report mention was made of the occurrence at Deeral of *Lepidiota caudata*, a reddish-brown cockchafer noticeably larger than *frenchi*, and slightly smaller than the greyback.

This insect, which breeds extensively in the neighbourhood of scrub lands, was observed about the end of September (1915) flying among plant-cane in sufficient numbers to alarm some of the Babinda growers. Up to the present, however, recent but very brief investigations at Deeral have not afforded evidence of serious injury to cane from attacks

of *caudata*. A native grass (*Paspalum platycaule*) appears to be one of its favourite food-plants, since out of 43 grubs collected at random from among roots of this grass on the 25th instant no less than 88 per cent. were *caudata*, the remainder being larvæ of *albohirtum*.

Second Brood of Grass-Caterpillars.

With further reference to the new noctuid moth-pest *Mocis frugalis*, mentioned on pages 29-30, I may mention that caterpillars of this insect belonging to a recent brood have again occurred at Gordonvale on young plant-cane, but this time very sparingly. In the present instance, however, the ground is free from weeds of any kind, and the insect has evidently selected the sugar-cane in preference to native grasses, &c., as being a suitable food for its offspring.

Fortunately this species is not likely to prove hurtful to cane-growers, as it is probably well controlled by natural enemies; but the present occurrence, although trivial, is not without significance, since it furnishes another illustration of the readiness with which certain insects will acquire a liking for cultivated plants closely related to those upon which they habitually subsist.

June 1916.

Experimentation against the grub form of *albohirtum* having been discontinued owing to commencement of the pupal stage, more time has been available for outside field-work, including a study of certain phases of the complex question of natural control, relating exclusively to conditions of a physical nature, which doubtless influence the economy of cane-beetles very materially.

New Cane-Butterfly.

Close examination of an extended area of plant-cane in the neighbourhood of Gordonvale has resulted in the discovery of another insect pest of this plant, which, although of very minor importance, deserves recognition, seeing that it has not been hitherto recorded as injurious to sugar-cane in Queensland.

The insect in question is the well-known Leaf Butterfly (*Melanitis leda* Linn.), ranging from Cape York to Sydney and occurring also in New Guinea and other countries. It measures about three inches across the extended wings, which are of a uniform chocolate-brown colour on the upper surface, merging into dull orange on the fore-wings, which are deeply scalloped on the outer edges and ornamented with a conspicuous black eye-like blotch enclosing two large white spots. The colouration of the lower surface varies from light to very dark purplish brown, and is crossed by a few blackish lines resembling the veining of a leaf, while the outer angles of the hind-wings are prolonged in the form of two short tails.

Both forms of the Australian race of this widely distributed insect —viz., *Melanitis leda banksia* Fab. and *M. leda banksia* Fab. *barnardi* Lucas—have been bred by the writer at Gordonvale from eggs deposited on leaves of sugar-cane.

This insect, which affords a capital example of protective colouration, does not fly far when disturbed, seeking rather to escape notice by dodging about in an erratic manner for a short distance and then settling

hurriedly on the ground or amongst withered leaves, &c., where it remains motionless, shutting its wings so as to expose to view only their leaf-like lower surface. The deception is so clever that unless one's eye has followed the insect closely and watched it alight there is small chance of locating the specimen.

Knowing the larvæ to be grass-feeders I was at first disposed to think their presence on cane might be accidental, but, later research having resulted in the discovery of both eggs and larvæ in widely separated plantations, there is little doubt that this butterfly, although of sparing occurrence in canefields, breeds habitually in such situations.

The pretty pale-green eggs, which are spherical, 1 mm. in diameter, and of glassy appearance, are laid side by side on the lower surface of a leaf-blade in batches of from three to eight.

The caterpillar is grass-green, sluggish, tuberculate, and about two inches long, the body tapering slightly towards each extremity. Owing to its colour and custom of resting on the lower surface of leaves it usually escapes detection, but when found is at once seen to differ from the larvæ of our other cane-pests in having two remarkable reddish or dark-brown horns rising vertically from the head, and a couple of pointed fleshy protuberances projecting horizontally from its anal segment. A number of these strange-looking caterpillars were bred recently at the laboratory, and just prior to pupation suspended themselves by the tail-end to the under surface of cane-leaves and the roof of their breeding-cage.

The pupa is one inch in length, stoutly proportioned, and of a uniform lovely shade of pea-green.

The larvæ of *Melanitis leda* feed openly, attacking the foliage only, occasioning injuries very similar in general appearance to those inflicted by caterpillars of the army worms *Cirphis unipuncta* Haw. and *loreyi* Dup.

No parasites were bred, but several pupæ succumbed to what appeared to be a bacterial disease (not yet identified), which caused them to blacken and decompose a few days after pupation.

Skipper Butterfly on Sugar-Cane.

While dealing with lepidopterous enemies of sugar-cane I may mention that several caterpillars of hesperid butterflies were collected this month from various plantations near Gordonvale.

The common Skipper (*Parnara mathias* Fab.), figured in Bull. No. 3 of this Office (p. 20, fig. 20), is evidently widely distributed in canefields, most hesperid larvæ collected here being of that species.

The following additional notes on the life-history of *mathias* will be of interest.

Its egg is dull yellowish white, dome-shaped, and deposited singly on the upper surface of cane-leaves. The caterpillars are much infested by larvæ of a tachinid parasite resembling a small house-fly.

It was noticed that individual caterpillars contained from two to four of these parasites, which after devouring the fluid contents of their host crawled out of its body and pupated openly on the leaf-blade close to the empty skin. Doubtless this fly renders valuable assistance in checking the increase of *P. mathias* and possibly other species of Hesperidæ.

The second species found attacking cane this month was *Telicota augias-kreffti* Macl., previously figured and described in Bull. No. 3 of this Office (p. 20, fig. 21).

July 1916.

PREDACEOUS ENEMY OF CANE APHIS.

The past month has been devoted chiefly to study of two phases of natural control affecting the economy of certain insect enemies of cane, viz.—(1) Meteorological conditions, with relation to their influence on the distribution and numerical increase of cane-beetles; and (2) predaceous insects, with special reference to a species predatory on some of our minor pests of cane.

Field investigations regarding the latter form of control have led to the discovery of a most beneficial orthopterous insect, an inveterate foe of the sugar-cane plant-louse (*Aphis sacchari* L.).

This interesting species, a small arboreal earwig, has attracted considerable notice in these parts, owing to its habit of flying very plentifully around acetylene lights, &c., on warm evenings, and often getting down one's neck. It was mentioned in a previous monthly report (p. 20) as being possibly predaceous, and having been observed at light-traps used for catching cane-beetles.

The adult insect, which varies in length from $\frac{1}{2}$ to $\frac{5}{8}$ inch, is of a general dark reddish-brown colour, with thorax, tegmina, and legs light yellow, and a conspicuous brown stripe down the centre of wing-covers. Its body is of polished appearance, and the anal cerci or forceps of the male are longer and more slender than those of the opposite sex, and much widened at the base internally in the form of an obtuse triangle.

This pretty earwig is most likely a species of genus *Labia*, but seems to have escaped the notice of systematists up to the present, since specimens submitted to the Australian Museum in 1915 were returned to me unnamed. Although excessively abundant throughout forest country, it habitually frequents canefields around Gordonvale, where numbers may be met with at all times of the year, either crawling over the foliage of stools or hiding behind withered leaf-sheaths and between the young unfolding leaves.

Whilst studying our Bud-Moth of sugar-cane in 1915, I found that its larvæ during confinement were devoured by this earwig, but results obtained at that time were not conclusive, no experiments being carried out under field conditions. The following evidence, however, resulting both from laboratory and field tests, affords ample proof as to its carnivorous tastes.

When confined separately in large test-tubes containing a portion of cane-leaf infested with plant-lice, four of these earwigs consumed between them 120 specimens in seven hours, an average of about 17 per hour. Upon being introduced into the cages they pounced without loss of time on the defenceless prey, seizing an aphis with their sharp mandibles and holding the succulent morsel aloft while engaged in chewing it. Each capture was generally followed by a quick backward movement of a few paces, the insect then standing motionless until ready for another mouthful.

It was amusing to watch these operations with the aid of a powerful reading-glass, and observe how little colonies of aphides scattered in consternation as the enemy walked coolly into their midst, and started to snap them up one after another with relentness indifference. The first victims were usually viviparous females of the wingless class; but larvæ, nymphs, and winged adults were also eaten with equal relish. The time occupied in devouring individual specimens varied from fifteen to twenty seconds.

An earwig was next allowed to run up the leaf of a large growing cane-plant on which aphides had been established and were breeding, its movements being closely watched under a magnifying glass. In about a minute after release, having travelled ten or twelve inches, it encountered an assemblage of plant-lice, and at once started to clear them off, eating a dozen or more with scarcely a pause, in a manner that left no room for doubt regarding the nature of one of its favourite foods under natural conditions. When examined four days later the foliage of this plant was perfectly clean, and not an aphis could be found.

The occurrence in Queensland of a predatory earwig of decided economic value should prove a matter of interest to sugar-planters generally, both here and in such countries as Porto Rico and Hawaii, where *Aphis sacchari* occasionally causes noticeable damage to cane crops.

In all probability we are largely indebted to the insect now brought under notice for the efficient control of our plant-lice in canefields, which, being always more or less in evidence throughout the Cairns district, would if unchecked soon multiply to an alarming degree.

September 1916.

LIGHT-TRAPS, POISON BAITS, &C.

It is proposed to pay further attention this season to the question of light-traps, not, however, with the object of attempting to protect a definite area of cane, but in order to test more fully the merits of the type of trap described and figured last March in the "Queensland Agricultural Journal" (vol. v., p. 226). Should time permit, these experiments will be supplemented by others designed to determine the relative value of suffused artificial lights of various degrees of illumination.

With regard to the trial of poison-baits for cane-grubs it has been deemed advisable by the General Superintendent to conduct field tests during the coming season on land planted last August, or early this month (September), and known to be grub-infested. These experiments will be along the lines advocated in a bulletin recently issued by the Bureau of Sugar Experiment Stations, entitled, "On the Value of Poison Bait for Controlling Cane Grubs" (Bull. No. 4, Div. of Entomology).

The rainfall recorded at Mulgrave Central Mill this month was 266 points, as against 52 points, the average for September during the last five seasons (1911-15); and, seeing that appearances at present point to the probability of a continuance of normal weather conditions, greyback beetles are likely to emerge in the vicinity of Gordonvale about the beginning of November. Owing to prolonged wet in the Babinda area, the reddish-brown cane-beetle *Lepidiota caudata* appeared on the wing at Deeral and adjoining localities about the 12th instant, nearly a month earlier than last year.

October 1916.

Effect of Arsenic on Cane Plants.

A series of laboratory experiments were commenced this month, to determine the action of arsenious acid and copper arsenate on growing roots of sugar-cane.

In pot experiments, the poison was—(1) sprinkled in a horizontal layer about two inches below sets; (2) dusted on cowpea leaves buried in similar position to the foregoing; and (3) mixed uniformly with the soil in which sets were planted. Rows of cane, exhibiting various stages of growth, from seed just sprouting to stools a foot or more high, were utilised for outside tests, the undiluted arsenicals in each case being dusted liberally over cowpea foliage, which was then placed in contact with the growing roots. We know that arsenic in soluble form exercises a burning action on foliage, but if sprayed on the earth loses at once its caustic properties, owing to the action of various minerals present in the soil. Investigations in Hawaii have shown that sodium arsenite, for example, when used as a weed-killer, and applied at the rate of 5 lb. per acre each week for six months (120 lb.), had no harmful effect on the growth of sugar-cane.

Torpidity of Cane-Beetles.

The rainfall for October was unusually heavy, 342 points having been recorded from the 13th to 31st instant.

In view of the very early appearance of *Lepidiota caudata*—mentioned in my last report—it is interesting to note that, although heavy rain fell at Gordonvale about the end of October, it was not followed by a general emergence of greyback beetles. Wishing to locate their position underground, an examination was made on typical red volcanic land at Meringa, with the result that several of these cockchafers were discovered lying in the subsoil at an average depth of about one foot.

The soil in contact with them was moist, but no attempt had been made to leave the pupal chamber and tunnel towards the surface.

Possibly the ground examined had not attained that precise degree of temperature which, together with suitable moisture content, appears to awaken this insect from its torpid condition, and transform it into an energetic worker, imbued with a burning desire to forsake its subterranean quarters as speedily as possible.

Centipedes Prey on Cane-Grubs.

With reference to predaceous enemies of root-eating Scarabæidæ, it may be of interest to mention briefly that various indigenous species of *Chilopoda* probably destroy a small percentage of cane-grubs.

The hideous appearance of our large Northern centipedes, coupled with the knowledge that they can inflict an exceedingly painful bite, inspires one with a natural loathing for these creatures akin to that felt for a poisonous reptile. A few of our large species appear to live almost exclusively in the ground, while others are frequently to be met with in old dwellings and outhouses, where they subsist mainly on big spiders, small frogs, &c. On more than one occasion I have observed them prowling about in such situations in the daytime, during very hot, sultry weather, their whereabouts in each case having been betrayed

by sudden loud croaks of alarm from the common green house-frog (*Hyla* sp.), which camps as a rule in old crevices, behind boxes, books, &c., and, although a noted consumer of cockroaches and other insects, is afraid to face the sharp jaws of a centipede, and evidently much resents its unwelcome presence. A repulsive bluish-brown species is not uncommon at Gordonvale and sometimes proves troublesome at the laboratory.

Towards the end of the month a specimen of this centipede, of formidable size, was detected in one of our breeding-cages full of soil containing larvæ of a small cane-beetle (*Neso flavipennis* Macl.). Finding a liberal supply of food (about fifty grubs) living in half a cubic foot of earth, it had taken up quarters there, with the intention doubtless of remaining, and had managed to dispose of several specimens, including pupal and larval stages of this beetle. The entrance mouths of two of its tunnels communicating with the surface of the ground were very noticeable, owing to the edges of same being partly encircled by a high ridge composed of minute particles of soil brought up from below.

November 1916.

Effect of Arsenicals on Cane Roots.

It is satisfactory to be able to state that experiments started at Gordonvale Laboratory last month to determine the action of copper arsenate and arsenious acid on growing roots of cane have yielded results of a most encouraging nature, and are now far enough advanced to admit of publication of a few details regarding this research work.

In the first test with arsenate of copper, short sets of Badila with three buds were planted in common 8-inch earthenware flower-pots, filled with sifted red volcanic soil. Pots 1 to 4 were infected at the rate of 113 lb. of Paris green per acre; the poison being mixed uniformly with the soil in pots 1 and 2, but buried in a horizontal layer a couple of inches below sets in 3 and 4. No. 5 was treated at the rate of 226 lb. per acre, thoroughly mixed with the soil; while Nos. 6 and 7 were untreated controls. These sets, which were planted on 3rd October, sprouted together, all producing healthy-looking shoots. Six weeks later, when the resultant plants were photographed (*see* illustration, "Australian Sugar Journal," vol. viii., p. 738), the mean height of foliage in Nos. 1 and 2 was found to be 15 inches; in Nos. 3 and 4, 18 inches; No. 5, 27 inches; and in 6 and 7, 15 inches. Nos. 1 to 5 had produced collectively 8 shoots, and Nos. 6 and 7, 5 shoots; the average height of foliage for the five treated pots being 10 inches, as against 7·50 inches for the two controls.

This seems to indicate that cane-plants may, perhaps, derive benefit from absorption by their roots of minute quantities of copper salts; since it is a well-known fact that in many cases we are able to artificially stimulate plant growth by applying weak solutions of copper sulphate to the soil. In the above experiment all the seven pots received the same quantity of water, sufficient to nicely moisten but be wholly absorbed by the earth, thus precluding drainage, and possible loss of fine particles of the soil or arsenic. Artificial manure consisting of a little nitrogen and potash was given at intervals in the water, each pot receiving exactly the same amount.

Results conveyed by the foregoing figures merely confirm previous opinions with reference to the action of Paris green given in last month's report.

The quantity per acre advocated in Bulletin No. 4 of this Office, in connection with cane-grub control by means of poison baits, was only 8 lb.; whereas it appears probable that at least 226 lb. per acre can, if desired, be administered to the soil in this way, without injury to the cane. Other experiments with Paris green yielded results practically identical with those given above, so need not be referred to in detail. I may mention, however, that the cane growing in a number of the 7-inch pots is higher at present in those treated with copper arsenate than in the controls, and finest of all in one containing cowpea leaves, that had been dusted with the arsenical at the rate of 113 lb. per acre. This experiment was started on the 1st instant, and five weeks later (5th December) foliage in these ten pots averaged about 18 inches in height.

As regards the action of commercial white arsenic, cane sets were planted on 4th October in half-a-dozen 10-inch flower-pots, and, when photographed after a lapse of six weeks, the average height of cane-leaves in those containing soil infected at rates of from 100 to 200 lb. of arsenious acid to the acre was found to be 27·80 inches, while in a single pot used as a control the height was 26 inches. All plants appeared equally healthy throughout the course of this experiment.

Outdoor tests were limited to an application of copper arsenite to roots of two months' old plant-cane growing near the laboratory, the poison being simply dusted over damp cowpea leaves, which were then buried about 6 inches deep on each side of stools, and 8 inches from the centre of the row. Plants treated in this way continued healthy, and developed in a normal manner. Five weeks later, when the soil was examined, the treated cowpea foliage was easily located, owing to its conspicuous green hue, but had, of course, partially decayed. The rainfall experienced during the course of the above-mentioned test was only 112 points, all of which fell on the 7th instant, about a week after burial of the poisoned leaves.

Notes on Emergence and Oviposition of Cane-Beetles.

The first emergence of *albohirtum* was noted by Mr. J. Clarke, of Highleigh, on the 7th instant, and at Meringa a week later.

Experiments were made this month to determine approximately the duration of the egg stage of *albohirtum* under varying climatic conditions. On the 27th a collection of greybacks was procured from the former locality (Highleigh), and twenty female specimens confined separately in cages of damp soil. When examined after an interval of 4 days (23 days after emergence) 14 out of these 20 beetles had between them laid 318 eggs, and the remaining 6 were constructing earthern chambers in which to oviposit. Half-a-dozen females derived from the above-mentioned collection, but placed on the same date in cages containing dry soil, did not lay; and ultimately, upon dying, 4 of them were found by dissection to contain 84 full-sized eggs fit for exclusion, and varying in individuals from 10 to 30 in number; while the ovaries of the other two were small and apparently unfertile.

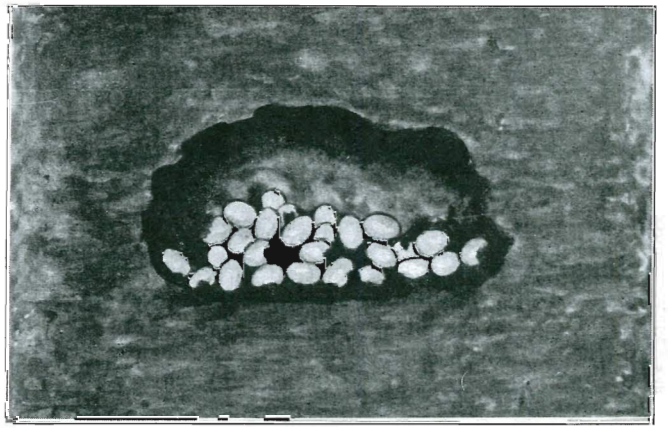
We may, I think, reasonably assume, from this foregoing evidence, that the simultaneous desire to oviposit manifested by the former batch of 20 beetles was induced by the ideal conditions of soil moisture that had been artificially provided, and, moreover, that the ovary in these insects had in most cases attained full development prior to the date of capture, but oviposition had been purposely postponed owing to abnormal dryness of the soil. It is hoped to deal more fully with this matter in a later report; but I may state that, apart from any scientific interest, these investigations have up to the present resulted in discoveries of more or less economic value in connection with control of the egg stage of *Lepidoderma albohirtum*.

December 1916.

Egg Stage of Cane-Beetle.

With further reference to the egg stage of our principal cane-beetle, alluded to in last month's report, it will be of interest to record the following data just obtained at Gordonvale Laboratory.

Dealing firstly with the method of oviposition practised by the grey-back beetle, I may state that the depth at which its eggs are deposited depends, naturally, to a great extent upon the amount of moisture in the soil at the time of deposition, which needs to be sufficient to keep them thoroughly damp during a period of at least two weeks. Practically all



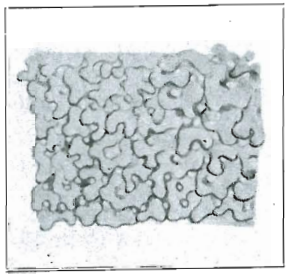
EGG-CHAMBER OF "GREYBACK" COCKCHAFER (NAT. SIZE).
E. Jarvis, original.

of the 73 specimens confined in moist soil at the laboratory this month oviposited at the bottom of their cages where the earth had been made wetter and firmer than that nearer the surface. Had there been more depth of soil they might have gone a few inches deeper.

Those laying large batches of eggs usually constructed a chamber of irregular shape, from 1 to 1½ inches long with sides more or less compacted, sufficient room being allowed for the eggs to expand during development. This cavity generally contained some loose earth, displaced most likely by the beetle as it crawled from the spot after having laid its eggs. These are placed in a flattened mass on the floor of the chamber, and may be produced separately or attached in

short strings of two or more, or in adherent groups consisting of as many as 17 (so far as observed); but as a general rule they are laid singly, and nearly always intermixed with small particles of soil.

The egg when first deposited is about 4·25 mm. long by 2·85 mm. in width, but during development gradually swells, until just prior to hatching it becomes more rounded, darker, sometimes brownish, and may measure fully 6 mm. in length (nearly ¼-inch). Being of a creamy-white colour, these large obtusely ovate eggs are naturally conspicuous when occurring in dark soils. The chorion or shell is somewhat coriaceous, finely and irregularly sculptured on the surface, as shown on the accompanying figure. With regard to the number that may be produced by a single specimen of *albohirtum* it is interesting to be able to state that results just obtained verify the correctness of previous opinions in this connection recorded last January ("Australian Sugar Journal," vol. ii., p. 902). Judging by numerous dissections made at that time, I concluded from the structure of the ovarian tubes that an individual beetle, although often laying from 24 to 30 eggs, was able to produce as many as three dozen—a number, by the way, much in excess of that given by other Australian entomologists, who have stated the maximum to be 24 or 25.



PORTION OF EGG-SHELL, × 80.
E. Jarvis, original.

During the present season, however, a female of this species, caged at the laboratory, actually deposited on the 8th instant a batch of 36 eggs; while from the ovary of another specimen a similar number was taken, fully grown and almost fit for ejection. In addition to the above high record it may be mentioned that two beetles laid 34 eggs each; and other lots, obtained from chambers formed in cages of damp earth, comprised eight batches of 30 eggs, three of 29, one of 28, one of 27, seven of 26, three of 25, and eight of 24.

The 73 females used in the above experiment produced collectively 1,537 eggs (21·5 per insect), but, disregarding specimens that laid less than 24 eggs, a total of 861 was obtained from 32 females, giving an average of about 27 eggs per insect.

When producing 20 or less, the eggs in such lots were generally a little larger at the time of deposition than those taken from chambers containing 25 to 36. Among batches of 30 to 36 it was not unusual to find two or three eggs much smaller than the rest.

The two ovaries (*see* p. 27) consist of twelve ovarian tubes connected with two oviducts which, together with the long, worm-like spermatheca, communicate directly with the vagina.

With regard to the duration of the period preceding oviposition, recent experiments incline me to believe that *Lepidoderma albohirtum* deposits only one large batch, which, in the event of emergence being followed by continuous dry weather, most likely includes every egg it is able to lay. On the other hand, should this interval prove more or less showery, oviposition may, and no doubt frequently does, take place as soon as each of the twelve ovarian tubes contains two fully grown eggs.

Under the latter climatic conditions, maternal instincts would naturally prompt the female to take advantage of the presence of abundant moisture in the soil; thus we may reasonably assume that the batch of 24 so often met with, consisting of eggs that usually mature simultaneously, would under such circumstances be laid first, while the remaining supplementary twelve, which apparently constitute a sort of reserve supply, and do not attain full development until some days later, would be deposited at random, either singly or in small numbers, as opportunity might offer. For example, the 73 beetles above mentioned chanced to experience a dry spell after emerging from the ground, and, egg-laying being delayed in consequence, some of them deposited the whole contents of the ovary in one large batch; while in no instance did a specimen subsequently yield additional ova, although living for several days longer, subjected to the same congenial environment.

With reference to the influence of parasites in this connection, it was noticed that a greyback beetle which harboured a single maggot of one of our small parasitic flies managed, notwithstanding, to mature and deposit 14 eggs about twenty days after emergence, and did not succumb until six days later.

Another beetle containing a large dexiid grub, and a third specimen infested with nine dipterous maggots, lived nearly three weeks, but were unable to oviposit.

January 1917.

Aerial Movements of Cane-Beetles.

With reference to investigations conducted this season to study more fully the nocturnal habits of our greyback cane-beetle, it may be of interest to record additional data relating to this insect, and to *Lepidiota frenchi* Blackb., a small reddish-brown scarabæid affecting cane. These observations were made at the Carrah plantation, near Gordonvale, on fourteen different evenings, between the hours of 6 and 10 p.m.; the artificial light used being an acetylene lamp giving an illumination of 21 litres.

The following notes briefly summarise results obtained between the dates 15th November to 28th December.

Unlike previous experience in 1914, many specimens of *albohirtum* that were attracted before daylight had quite disappeared. Early in the season (15th to 25th November) flight commenced at 7 p.m., phototropic reaction generally taking place about 20 minutes later; whereas, during December 1914 the time spent on the wing prior to entering the light-trap was just 40 minutes (7.20 to 8 p.m.).

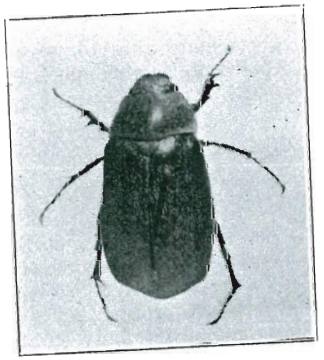
This species displays great aerial activity when the thermometer stands above 80 deg. and not lower than 75 deg. Fahr., but at 70 deg. F. it flies less freely, while a low temperature such as 65 deg. F. apparently stops flight altogether, and renders the beetles torpid.

The duration of the period usually passed on the wing each evening depends too, very materially, on the amount of moisture in the ground. Emergence of the beetles this season was not followed by showery weather, and in proportion as the surface soil each day became drier the time occupied by flight during twilight decreased very noticeably. On 21st November, for example (seven days subsequent to the appearance

of this insect), *albohirtum* flew for about 25 minutes only, the temperature at the time being 76 deg. F.; and a couple of days later, the weather still continuing very sultry, not a single specimen was heard flying at the usual hour, although the dry bulb registration was 78 deg. F. This failure of *albohirtum* to appear on the wing was noted again on 25th November (75 deg. F.), when, however, numbers of *Anomala australasiæ* Blackb.—a small cane-beetle of a deep bronzy-green colour—were observed at dusk circling about, and settling on the foliage of certain native shrubs. Further scientific data respecting the phototropism of *albohirtum* was obtained, but need not be recorded here.

Flight of Lepidiota frenchi Blackb.

On 13th to 14th December heavy rain fell at Meringa, and was at once followed by the primary emergence of *frenchi*. This well-known reddish-brown cockchafer, which occurs practically throughout open forest country, proved excessively abundant. Its larvæ subsist on roots of grasses and various herbaceous plants, but frequently attack sugar-cane, and doubtless are responsible at times for much damage to this plant. At Carrah this season ample opportunity was afforded for studying the aerial movements of *frenchi*.



Lepidiota frenchi Blackb. (1½ times nat. size). *Photo., W. C. Dormer.*

Flight commences upon the first approach of twilight (6.45 p.m. on the occasion in question), when suddenly, and without warning of any kind, myriads of these beetles start up simultaneously from every quarter, and wildly dash to and fro, as though determined to exercise their wings to the utmost. The scene strikes one as being decidedly novel, and, apart from its scientific aspect, well worth witnessing.

Standing among the cane-stools, one seems to be encompassed by an immense swarm of beetles—thousands being in view at the one time—which, in their erratic and ill-directed flight, are constantly striking against the cane-leaves, the clapping noise produced by the sudden impact being plainly audible at a distance of several yards. In addition to this oft-repeated sound, the air, so still before, vibrates loudly with a continuous hum, due to the accumulated buzzing of countless numbers of these insects. Although scarcely within the province of a monthly progress report, it may be of passing interest to mention that I found this humming note to be B natural—eight tones below the middle C of a piano at concert pitch—and very different from the deep tremulous drone that characterises the flight of our greyback cane-beetle.

The turmoil I have tried to depict lasts only for about ten minutes, and then, ceasing as abruptly as it began, is immediately succeeded by copulation. At this stage the beetles may be seen on all sides clinging in couples to the cane-leaves at a height of three or four feet above ground level. If picked off from the foliage they will lie quietly in the hand, still united, without making the least attempt to escape.

As previously pointed out in 1915 (p. 11), plantations allowed to remain weedy while this cockchafer is on the wing are likely to be

invaded by the beetles. I have to record that conclusive proof of its having acquired a decided liking for cane was obtained last month, when, upon examining land at Meringa that was under thoroughly clean cultivation, both eggs and newly hatched larvæ of *frenchi* were discovered among the main roots of the cane, within an inch or two of stools.

Laboratory experiments were started this month to determine the effect of different stomach poisons upon young larvæ of *albohirtum*. This line of research work has necessitated the design and construction of special apparatus, by means of which we hope to study the movements and tropic reactions of a grub to various stimuli whilst it is in the soil.

February 1917.

During the past few weeks the subterranean movements of first-stage larvæ of our greyback cockchafer have been studied to some extent, and we hope to publish a few results in this connection next month.

Grubs of this beetle, having now moulted to the second and third stages of growth, are capable of doing great damage, but happily up to the present have not turned up under the plough in alarming numbers.

No word has come to hand of serious infestation in the Gordonvale and Meringa districts; and, according to report, the cane at Greenhills looks remarkably fine, and is expected to yield about forty tons to the acre.

COLLECTING CANE-BEETLES.

Beetles were not received last season by the Mulgrave Central Mill, and although uncollected appear on the whole to have been less numerous than usual. Experience in Queensland, however, during the past fifteen years or more is said to have demonstrated the value of this means of repression, which is, by the way, one of the very oldest forms of control ever advocated by economic entomologists. Such procedure, coupled with that of destruction of feeding-trees of the beetles, would naturally and at once suggest itself, even to an outsider, as being likely to prove beneficial.

With regard to the former remedial method, it may be mentioned that many leading entomologists recognise its possibilities as a practical means of checking the increase of root-eating scarabæid larvæ. In parts of Europe, for example, where the so-called "May Bug" or cockchafer (*Melolontha melolontha*) causes such immense damage to timber and various crops, collecting the insects by hand is believed in some cases to have yielded appreciable benefit. In Russia during 1913, 15 tons of these beetles were collected, at a cost of £200, from an area embracing about 23,000 acres of forest land; while in the previous year (1912), in the Government of Tambov alone, no less than 25 tons were captured and destroyed. The price paid per pound weight in Russia varies from ¾d. to 1½d., this work being done mostly by women and children. In our own country, scarcity of labour and the high price paid for beetles (6d. to 9d. per lb.) are likely, I think, to prove serious obstacles to success in this connection.

Such collecting, to be of any real benefit, should not only be practised systematically and on an extensive scale, but also be under the direct supervision of an entomologist, in order that the nature of the results

obtained may be fully understood, and control measures concentrated on such districts as may have been found—by investigations made just prior to emergence of the beetles—to be grossly infested, and, therefore, likely to best repay the monetary outlay incurred.

Destruction of Feeding-Trees.

Referring to the question of destroying food-plants of the beetle, I may say that there can be little doubt as to the importance of this means of repression. On the Johnstone River, for instance, it was noticed that in certain cases the destruction of timber affording harbourage for the beetles along fringes of creeks, &c., was quickly followed by an almost total disappearance of the grub-pest ("Australian Sugar Journal," vol. vii., p. 344).

Such, too, appears to have been the experience of Mr. W. Irvine, of Highleigh near Gordonvale, who, having closely watched the gradual spread of our greyback beetle during the past twenty years, kindly furnished me with a few interesting particulars regarding its first appearance in this district. In the early days Mr. Irving's cane was badly grub-eaten; but he soon obtained permanent relief simply by destroying a belt of timber situated not far from his residence.

It must not be inferred from the foregoing remarks that I am in favour of an indiscriminate destruction of all feeding-trees. The success of this remedial method, as already pointed out on page 24, depends to a great extent on the geographical situation of an infested canefield, the position of timber in its immediate vicinity, and on neighbouring topographical conditions.

Influence of Topographical Conditions on Grub Infestation.

Certain plantations near Gordonvale have long been severely attacked by cane-grubs. Take as an illustration a notorious section of land at Meringa embracing several selections situated not far from the township.

The ground in this locality is typical red-volcanic, a class of soil much favoured by cane-grubs because of its friable character, which allows more freedom of movement than is possible in heavy clay-loams, &c.

The area of land in question (*see* Plate I.) is bounded on the south-west and north-east by forest country, supporting feeding-trees and other food-plants, the belts of timber forming the southern and western boundaries being closely backed by chains of mountains, that unfortunately happen to be in such position as to form a kind af extensive pocket, the mouth of which directly faces the normal line of flight. Great numbers of beetles are liable to be transported during migration into the centre of this area by the south-east trade wind, and finally come to rest on timber fringing the northern and western headlands of the selections above mentioned. A mountain range lying to the west serves to intercept beetles that may occasionally be carried in that direction; and which, continuing their flight northwards along the base of this obstruction, must ultimately reach the pocket in question. Having arrived there, and joined forces with the other beetles, the almost semicircular wall of ranges at the back of this huge natural cul-de-sac constitutes an effective barrier to further progress in a north-westerly direction; while

the trade wind—which usually prevails during nine or ten months of the year—tends to prevent any beetles from returning southwards. Being compelled, therefore, to remain and breed in the vicinity, it follows as a matter of course that plantations adjoining forest land fringing the base of these ranges are likely to suffer more or less severely each season.

Want of space forbids further comment, but the above will suffice to show that, before destroying feeding-trees on an extensive scale, the various factors associated with this control method should be taken into account.

March 1917.

Parasites of Cane-Beetles.

A new tachinid fly was bred by the writer last January from a specimen of the greyback cockchafer. This parasite, which strongly resembles a large house-fly, is nearly ⅜-inch long, and of strikingly handsome appearance; the head and thorax being dull golden, the latter striped longitudinally with two broad blackish bands, which on the prothorax are ornamented by a central streak of the same rich hue. The basal half of scutellum is blackish, while the dark reddish-brown abdomen is barred transversely with three silvery-white bands, and bears towards its extremity a number of stout bristles.

It was found that a female of *Lepidoderma albohirtum* infested by a single maggot of this tachinid fly was able, notwithstanding, to mature and deposit fourteen eggs before succumbing to its injuries. This beetle, however, was collected from outside, so, although living a fortnight in confinement, may, of course, have been parasitized just prior to the date of capture.

The eggs of such parasitic diptera are often deposited externally, being firmly glued to the body of the host in such position as to render removal difficult, and to enable the tiny larvæ, when hatched, to bore at once through the skin of their victim preparatory to feeding on its internal tissues.

Judging by the size of *albohirtum* we may assume that the parasite in question normally lays two or more eggs on a single beetle, in which case the resultant maggots might soon inflict serious injuries, and by destroying the ovaries of their unfortunate host prevent it from ovipositing.

Note.—Subsequent breeding experiments made by the writer during 1923 go to show that single specimens of *albohirtum* (beetles) often harbour two maggots of this parasite.

Our greyback is, I think, very liable to victimisation by dipterous parasites, owing to its habit of remaining on the feeding-trees all day in a motionless or semi-torpid state, fully exposed to assaults of such insect enemies.

The only other tachinid bred at Gordonvale from the imago form of *albohirtum* was a small fly, $\frac{5}{16}$ inch in length, with dull yellow thorax and legs, dark reddish-brown abdomen, and blackish head. This insect, which was first noticed in 1914 by my assistant, Mr. A. P. Dodd, but has not yet been identified, is evidently an abundant species. Numerous specimens were bred by the writer last season (1916), the number of maggots found infesting a single beetle varying from three to twelve.

Alluding very briefly to other dipterous parasites bred here during the past two years from various species of root-eating scarabæid larvæ affecting cane, I may mention that these include no less than eight different kinds of Dexiidæ and four of Asilidæ; the former resembling in shape gigantic blowflies, and being frequently adorned with brilliant metallic tints of greenish gold, blue, or deep crimson; while the latter (Asilidæ), familiarly known as "Robber Flies," are predaceous insects, with stout, moderately long bodies, hairy for the most part, and of obscure colouration.

These dexiids and asilids infest the grubs of about eight species of our cane-beetles, but apparently are too rigorously controlled by insect and other enemies to be of much economic value here.

In addition to the foregoing, our scarabæid grubs frequenting cane-fields are preyed upon by at least one species of elaterid larva, and four species of digger-wasps (Scoliidæ), which in their turn are kept in check by hyperparasites belonging to the families Bombylidæ and Rhipiphoridæ.

April 1917.

Grubs of Lepidiota frenchi Damaging Cane Roots.

Grubs of the greyback beetle are now in the third stage, and about to pupate.

Greenhills plantation is reported to be suffering severely this season, 300 acres or more being badly affected; and the pest is also doing great damage in the Highleigh and Aloomba districts.

Whilst ploughing cane land in April and May, one frequently turns up numbers of small grubs about $\frac{3}{4}$-inch long, which, occurring in association with third-stage *albohirtum* measuring $1\frac{3}{4}$ inches in length, are erroneously believed by most cane-farmers to be young larvæ of the greyback which have emerged from eggs laid during the present season; while they suppose the others to be full-size grubs of the same beetle that were hatched the previous year. It may interest growers to learn, however, that these small larvæ in evidence just now represent the second stage of *Lepidiota frenchi*, a destructive scarabæid beetle of a dark reddish-brown colour, figured in Bull. No. 3 of this Office (p. 37, fig. 41). (*See* p. 42.) Its metamorphosis occupies a period of two years, whereas the complete life-cycle of *albohirtum* (from egg to perfect insect) takes only twelve months.

Although both these beetles oviposit during December or January, grubs of the latter species attain full growth in a space of about six months (January to June), pupating, as a rule, from July to September.

Those of *frenchi* on the other hand, which mature very slowly, remain in the larval stage for fully a year longer; thus accounting for the presence this month (April) in the same furrow of large and comparatively small grubs. Owing to its two years' life-cycle, second and third stage grubs of *frenchi* are both procurable during winter months, while this species is noticeably injurious to cane every second year, when its larvæ are in the third stage.

Fully grown grubs of *frenchi* are usually mistaken for those of *albohirtum*, which they closely resemble in size and general appearance, but the former may be noticed every second year when ploughing from

August to December, at a time of year when no third-stage larvæ of *albohirtum* are to be met with. The specific distinction between grubs of these two beetles may easily be determined by examining with a pocket-lens the under surface of the last body-segment, on which numerous bristles will be seen, arranged in the manner shown by accompanying photos. (pp. 47-48).

Arrangement of Bristles on Anal Segment of Grub of *Lepidiota frenchi* Blackb. (highly magnified).

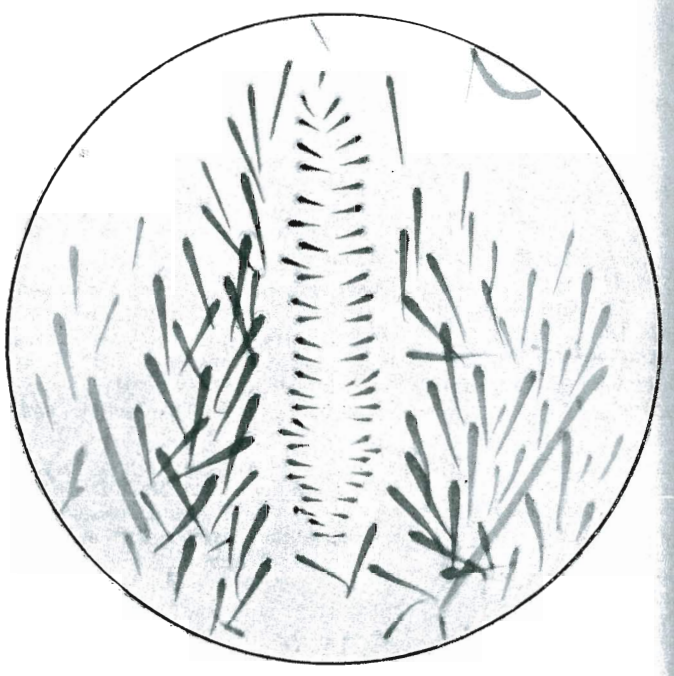
Photo., W. C. Dormer.

A decided outbreak of *frenchi* occurring recently at Meringa on volcanic soil was investigated on the 30th instant, when 186 second-stage grubs were collected in a few hours from 50 chains of furrow—representing about 2,418 grubs per acre, or 0·85 per cent. to each stool of cane.

Although one of our serious cane-beetles, second to *albohirtum* in economic importance, this insect, fortunately, oviposits as a rule in uncultivated soil densely covered by grass or weeds, &c. This being the case it behoves growers to maintain, during December and January, a system of clean culture on areas devoted to cane, and more particularly on land that may be reserved for early planting. Both *albohirtum* and *frenchi* lay eggs during these months, and are strongly attracted by a luxuriant growth of vegetation between the rows, so that land in a weedy condition is almost sure to become badly infested.

The latter insect (*frenchi*) usually oviposits freely in such situations, with the result that, when ploughing for an early crop in May or April is in progress, the grubs from these eggs, 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.



Arrangement of Bristles on Anal Segment of Grub of *Lepidoderma albohirtum* Waterh. (highly magnified).
Photo., W. C. Dormer.

May 1917.

FIELD EXPERIMENTS WITH POISON-BAIT FOR GRUBS.

Referring briefly to field experiments with poison-bait for cane-grubs, carried out lately at Innisfail and Meringa along the lines advocated in Bull. No. 4 of this Office, I may say that in the former district a couple of acres were treated by Mr. F. L. Sugden, but owing to scarcity of grubs this season no damage to his crop was perceptible, either on this area or on immediately adjoining untreated cane land; so that the result of the experiment is doubtful. "One important point, however," writes Mr. Sugden, "appears to be definitely proved, that the application of even a heavier dose of Paris green than you advised has had no injurious effect, but rather the reverse, on the growth of the crop." The foliage of cane treated at Innisfail was noticed to be more luxuriant and of a darker green than that on the untreated area.

The above conclusion arrived at by Mr. Sugden verifies the writer's opinion with respect to treated cane grown in pots at the laboratory last October (*see* pp. 36-38). Our half-acre plot at Carrah Estate,

belonging to Mr. A. J. Draper, was treated with bait consisting of cowpea foliage dusted with copper arsenate. The peas, which were sown 25th January, in trenches alongside of cane planted last August, were duly poisoned and covered over on 14th February, the arsenical being applied at the rate of 24 lb. per acre. Early in March the plantation on each side of this test-plot—with the exception of a strip 9 chains long, containing ¼-acre adjoining its southern boundary, and about 3 acres on the northern edge of the 30-acre block—were fumigated by Mr. Draper with bisulphide of carbon. At present the cane on our experiment plot is fully 8 feet high, and quite as flourishing as that growing on soil that had been fumigated.

The control ¼-acre appears to be suffering slightly, but as the plants are 6 feet in height one can examine only the end of this strip, which is about 20 feet wide. To form a correct idea as to its condition it would be necessary to look down on it from above, and compare the height and colour of the leaves with that of the cane on either side. The three untreated acres on northern boundary, however, are already affected in places.

Presuming that grubs occurred early in the season over the entire area of this 30-acre block, we may I think reasonably conclude that arsenical poison-bait will destroy them just as effectively as fumigation with carbon bisulphide.

The weather during the entire course of this experiment has been more or less showery, thus allowing affected plants to root afresh, and keep fairly green. In the event of normal dry conditions setting in we may expect to see more definite indications of grub attack on these check-plots at Meringa.

June 1917.

Work has recently been devoted principally to the study of the external anatomy and metamorphosis of certain of our more injurious cane-beetles. An illustrated bulletin dealing with the habits and life-history of *Lepidiota frenchi* Blackb. was prepared by me and submitted to the Bureau of Sugar Experiment Stations. I may state that the MS. in question embodies an account of the eggs and early larval instars—hitherto unknown to science—together with a scientific description of the imago stage; while noteworthy specific structural differences between this insect and a closely related cane-beetle (*Lepidiota consobrina* Girault —formerly *Lepidiota No. 683*) are also discussed and figured where necessary.

"SKIPPER" BUTTERFLY ATTACKING CANE.

I wish to record the occurrence at Gordonvale last May of a new lepidopterous pest of minor importance affecting sugar-cane.

The insect in question is an hesperid butterfly (*Padraona hypomoloma* Lower), a detailed description of which has been published by Lower (Revision of Australian Hesperidæ, Trans. Royal Soc. South Australia, vol. xxxv., 1911), who records its previous occurrence at Herberton and Kuranda in March, and near Sydney in April.

At Gordonvale the caterpillars of this butterfly destroyed the leaves of young cane-plants growing in pots placed on the veranda at the laboratory. Although measuring scarcely an inch in expanse, its dark-brown wings contrasted with rich orange yellow render it a fairly

conspicuous insect, the latter colour being arranged on fore-wing in the form of an oblique stripe near outer margin, and a large triangular blotch on costa, while a broad transverse band of the same colour, placed between two spots, crosses the middle of hind-wing.

The pupa, which is about ⅜-inch long, is pale brownish yellow, with a dull-red U-shaped plate on dorsal surface of anal segment, bearing two very short, pointed horns, that part of the edge lying between them being scalloped, and the extremity of the anal segment flattened vertically and furnished with numerous yellow bristles.

This is the fourth species of Hesperidæ found attacking cane near Gordonvale, the other three—two of which occur also on cane in Java—having been recorded in Bull. No. 3 of this Office (pp. 22 to 25). Since its publication, however, an additional butterfly (*Melanitis leda* Linn.), and a moth (*Mocis frugalis* Fab.), have been mentioned in monthly reports as occasionally destructive to the foliage of cane-plants; so that our list of cane-pests now includes sixteen lepidopterous insects.

Note.—A special bulletin dealing with several new lepidopterous pests affecting sugar-cane in Queensland was published by the present writer in 1920 (Bull. No. 9, Div. Ent. Queensland Bureau of Sugar Experiment Stations).

June 1921.

Grubs in the Cairns District.

When again given charge of this Entomological Laboratory on the 19th of last month, I naturally endeavoured in the first place to review the cane-grub situation from an economic standpoint, and to summarise as far as possible the results of various activities of this station during the period (July 1917 to May 1921) occupied by the appointment of Dr. J. F. Illingworth.

Although climatic conditions have been very favourable to the growth of cane, the outlook is anything but encouraging, grubs having appeared in numbers this season at Mulgrave, Hambledon, Highleigh, and elsewhere, on river-flats, and places which for many years past have been fairly free from attack; while at Greenhills, that stronghold of the grub-pest, about 300 acres of cane are badly affected.

Such widely spread injury, occurring as it does at a time when the beetles during the last three years have not been collected in the Cairns district, and had a chance to breed and multiply a hundredfold, must appear significant. As a matter of fact, economic entomologists the world over have long recognised the importance of systematically collecting the grubs of many injurious species of root-eating Scarabæidæ. For instance, in a recent bulletin (1918) issued by one of the sugar experiment stations at Porto Rico, we read: "The most successful method of controlling the 'white grub' that has yet been found is that of collecting the grubs and beetles. The method is rather expensive, but it is the only way of keeping the pest from increasing." Again, our State Entomologist, Mr. H. Tryon, at a meeting of the Australian Sugar Producers' Association in Maryborough (1911), stated that "these measures" (viz., collecting) "had in the past accomplished very great results. It was only when these measures had been neglected that grubs had increased to a disastrous extent."

How to Use Arsenic.

At Gordonvale during the years 1915 to 1916, I studied the effect upon cane-grubs of several deadly poisons administered in various ways, and, after demonstrating the extreme resistance of our cane-grubs to stomach poisons, ultimately found that the only way in which to secure a high percentage of mortality was to induce them to devour some kind of palatable bait liberally treated with the poison in a concentrated form.

Paris green and white arsenic gave the best results, the former arsenical proving the more deadly of the two (*see* Bull. No. 4 of this Office). A field experiment along these lines was conducted by the present writer in February 1917, when a bait consisting of cowpea foliage dusted with the above arsenicals at the rate of 24 lb. to the acre was turned into the soil against the stools, the result being decidedly encouraging (*see* pp. 48-49).

Later, in 1919, when the cane on our Meringa experiment plots was harvested, it transpired that the highest yield (29·4 tons per acre) was obtained from Block 10, which was treated with white arsenic at the rate of 10 lb. per acre, dusted on wet Mauritius beans and ploughed in; while the lowest yield (16·658 tons per acre) was derived from an application of sodium arsenate, sprayed in the drills at the rate of 10 lb. per acre.

The above results appear to justify conclusions arrived at in 1915-16, and to indicate that arsenic, to be effective, should be administered as far as possible in a concentrated form; moreover, when sprinkled loosely in the drills, heavy rain tends to wash the minute particles of arsenic downwards, thereby causing additional and far greater soil adulteration. When laying out future experiment plots of this kind, it is proposed to institute a number of methods of administering arsenic that have not hitherto been tried in the field.

Localities Visited.

On 30th May a visit was made to Hambledon plantation, where, owing to the courtesy of Mr. F. C. P. Curlewis, I was able to look at some of the cane-farms and note degrees of grub-infestation. It was interesting to find that D. 1135, which at first had appeared likely to resist attack in that locality, was finally succumbing in several places, and fast turning yellow. A block of this variety, planted June 1920, had shown the first indication of grubs the following April, and is not expected to cut over 20 tons. A late block of the same variety, planted in September, went down in March; whilst 8 acres of Clark's Seedling, planted at the same time, collapsed during May, and might cut 5 tons, although in January (about five months after planting) it had every appearance of being a 30-ton crop. Mr. Curlewis directed my attention to one of those problems so full of interest to the entomologist, the solution of which might at any time throw considerable light on the question of cane-grub control. This was a 15-acre block of H.Q. 426, June planting, that was stunted, and for the most part grub-eaten—having dropped from an anticipated yield of 30 to about 15 tons—while right alongside it, on similar soil, stood a small block of D. 1135, planted the same month, but apparently free from grubs, the sticks being 7 to 9 feet high, and promising about a 25-ton crop.

Aloomba was visited on the 3rd and Woree on the 21st instant, when inquiries were made at both places into the reported occurrence

in injurious numbers of the beetle-borer of cane (*Rhabdocnemis obscurus* Boisd.). In each case, however, these alarms were proved to have been groundless.

Cairns Show Exhibit.

On the 8th instant we exhibited at Woree a small collection of insects, &c., comprising eggs, larvæ, pupæ, and adults of our various cane-beetles, together with a number of the parasitic and predaceous enemies, such as digger-wasps and robber flies, that help to control the ravages of the grub-pest. This display afforded opportunity for getting into touch with cane-growers, and led to much instructive discussion relative to the cane-grub problem.

July 1921.

Introduction of Parasites.

This matter being considered of importance, preliminary steps have been taken to get into touch with entomologists in those parts of the world where species of scoliid wasps likely to prove serviceable here are known to occur. Several kinds of digger-wasps are obtainable for introduction, and very probably some of them might do valuable work in our canefields.

Before going to the expense of introducing any parasitic insect, however, knowledge of certain facts relating to its life-cycle, economy, and environment is essential; since in the absence of such data it would be impossible to decide whether a species, if introduced here, would in the first place be likely to live in Queensland; or, if so, find suitable host-grubs, or breed in a normal manner.

With view to obtaining reliable and comprehensive information of this nature regarding certain species of Scoliidæ that in the writer's opinion seem likely to meet our requirements, a list of questions has been prepared, which, when replied to by the various entomologists approached, will considerably illuminate the matter, and enable me in the near future to report more definitely on this interesting form of control.

Bacteriologists who are at present experimenting with different diseases affecting grubs of cockchafer beetles have also been consulted, and it is hoped that a measure of relief may be secured through the introduction of suitable bacteria, which under our warm climatic conditions should thrive and multiply abundantly.

Fumigating Cane-Grubs.

Since the manufacture last year, by Mr. Dawson of Gordonvale, of a machine for administering carbon bisulphide to the soil, the merits of this fumigant have been rather freely discussed here, and we propose to look into the matter this season and conduct a series of field experiments.

Mr. W. F. S. Howe (manager of Mulgrave Central Mill) happens to have had considerable experience with carbon bisulphide, and obtained results against mature cane-grubs which appear conclusive.

I am inclined to agree with him in thinking that many of the failures in past years resulted from applications having been made either at the wrong time—viz., when the soil was too wet—or in heavy land

not properly cultivated. The best results are usually secured in well-worked volcanic or clay-loam soils at a time when these are thoroughly moist, but not wet enough to affect porosity. Such conditions generally obtain in light soils about a couple of days after heavy rain; but it is best to make sure by testing one's land with a spade.

Although carbon bisulphide is much used by entomologists for controlling various soil-frequenting insects, it does not seem to have come into general use here against cane-grubs. This may be owing to the following reasons:—

(1) Its rather high cost;
(2) The expense of distributing it by hand-injectors;
(3) Difficulty of obtaining reliable men to apply it;
(4) Want of knowing exactly *how* and *when* to apply it;
(5) Doubts regarding the efficiency, or after-effects, of such fumigation.

Now, by adopting some reliable mechanical treatment we at once get rid of objections Nos. 2 and 3, since our field application would then be performed quickly, systematically, and with certainty, two rows of cane being treated at once by the machine as it passed along between the stools, while the labour involved would consist simply of a driver and one horse. Seeing that such treatment is not practicable after cane reaches a certain height, fumigation would need to be commenced as soon as possible after flighting of the beetles; for by making an early start we secure a period of two months or more in which to treat young ratoon and late-planted crops. It is proposed, therefore, to direct experimentation during the coming season against the eggs and small grubs, the latter of which will doubtless succumb to ordinary fumigation.

Little or nothing is known regarding the effect of bisulphide on the eggs of scarabæid beetles, but I am inclined to believe the fumes would penetrate the soft and rather absorbent chorion (egg-shell) of *Lepidoderma*. However, this is a point to be determined shortly. Our interest at present centres in the machine and its possibilities, which it is hoped may be completed this season in time for Mr. Dawson to give a practical demonstration in the field. If successful, it might pay us to advance another step, and, as suggested by Mr. Howe, manufacture our own carbon bisulphide, and so reduce the cost about one half, which would satisfactorily dispose of objection No. 1.

August 1921.

Station Improvements.

The present season having been very favourable for planting, some attention has been bestowed on station improvements of a general character, requiring to be carried out during winter months.

Experimentation with Deterrents.

We propose during the coming season to take up this line of control work, which, although previously touched upon by Mr. Tryon about twenty-five years ago, has not since been followed up, or submitted to scientific investigation.

The use of deterrents has long been advocated by economic entomologists as a method of coping with many kinds of insects, and of late years attempts have been made in other countries to employ this form of control against the white grubs of root-eating scarabæid beetles.

Our choice of repellents, however, is naturally limited to substances harmless to cane, that can be handled without danger, are easily applied, and are inexpensive or moderately so. Preferably they should be of manurial value, and admit of application in a dry form.

Mr. A. J. Draper has kindly allowed us to experiment in this connection on the Carrah Estate, where I have already selected a portion of a block of D 1135, June planting, that is now about eighteen inches high and looking well. I need hardly say that this form of control will be directed against the beetle itself, our object being to deter if possible the egg-laden female insect from entering the ground to oviposit, by previously rendering the surface soil around the cane stools obnoxious in some way.

Collecting Cane-Beetles.

As already pointed out in a previous report (1915), we must not lose sight of the fact that, in problems such as that now facing us, entomologists have always considered that ideal control methods are essentially those in which we succeed in capturing the female insects before they have had time to deposit eggs.

The Cairns Cane-growers' Association published in the "Post" this month a few suggestions offered by the present writer regarding future collecting of grubs and beetles, inviting cane-growers to freely criticise same and recount their experiences in this connection.

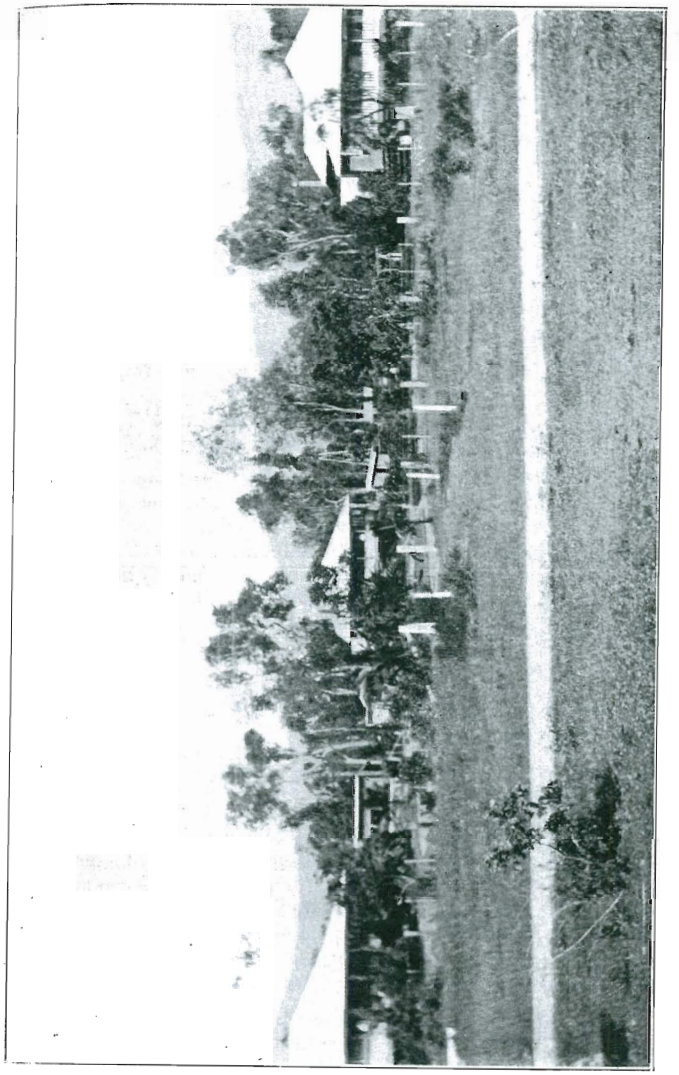
Regulation No. 4 of these suggestions stated that grubs should be collected from cane-lands only or in the immediate vicinity of same, and beetles from within a radius of about a quarter of a mile from cane-land. Apparently, some of our growers do not even yet realise that leading entomologists as a whole, after working for more than thirty years at the white-grub problems, assert that up to the present no better control method than that of systematic collecting has been discovered. We naturally recommend this method to growers, because it has stood the test of practical application, particularly in Europe and America.

One of the latest examples of such work is reported from Mauritius, as follows:—"The number of *Lachnosterna* (cane-beetles) captured in 1919 to 1920 was under 31,000,000, as compared with over 71,000,000 in the previous year, and is the lowest since 1912-1913. The figures indicate that a control has been established in those areas in which the infestation originated; it is only in the more recently invaded part of the area that the number of beetles taken is still on the increase. This view is corroborated by results of surveys for the larvæ."

In 1914 we ourselves collected 22 tons of beetles in the Cairns district, which represent more than 8,000,000 specimens, a number able to destroy 11,000 acres of cane, which, if producing an average (say) of 15 tons per acre, would mean a loss of 165,000 tons. Since the average annual loss in the district of Cairns is estimated to be about 30,000 tons of cane, it appears that the 22 tons of beetles captured in 1914 were capable of causing injuries amounting to more than five times that of the whole of our annual loss from grub attack. Even if less than one-quarter of these beetles had oviposited in the canefields around which they were collected, we should, as a result of this control method, have prevented destruction of about 40,000 tons of cane, an amount exceeding that of our annual loss throughout the Cairns district.

The above facts are mentioned here because I hope to show later on that our most badly grub-eaten areas of cane-land around Gordonvale have been gradually invaded by this pest, which first started its encroachments about the year 1897.

Plate III.



ENTOMOLOGICAL STATION, MERINGA; AS SEEN FROM CAIRNS ROAD. *Photo., W. C. Dormer.*

With regard to the distance from cane from which beetles might be profitably collected, I think a quarter of a mile would be insufficient. Such limitation, however, would certainly concentrate the work upon an area harbouring beetles that would be very likely to trespass on adjoining cane-land.

If few collectors were employed the above-mentioned distance might suffice, while in the event of many hands being available it would, I think, be advantageous to work the feeding-trees farther back. We know that beetles will visit cane half-a-mile away, but, unfortunately, we do not know definitely whether they will fly twice or three times that distance in order to attack cane. Under normal climatic conditions a mile is probably the limit from which we need fear invasion, but should windy weather chance to occur during nightfall, as sometimes happens, whilst beetles are on the wing (from 8 to 10 p.m.) they are then liable to fly far afield.

Trapping Beetles in the Field.

In 1916, while at Gordonvale Laboratory, I pointed out the desirability of capturing female beetles during the critical period of egg-laying, by means of light-traps placed among the cane (*see* "Australian Sugar Journal," vol. vii., p. 903), and emphasized the fact that the beetles directly responsible for future trouble were those which, having managed to elude capture from feeding-trees, finally visited the canefields at night-time in order to oviposit. Growers are advised to look up this special report. I hope this season to devise some new form of light-trap, based on the design of that figured in the above-mentioned report but of simpler construction, with which to follow up this line of control.

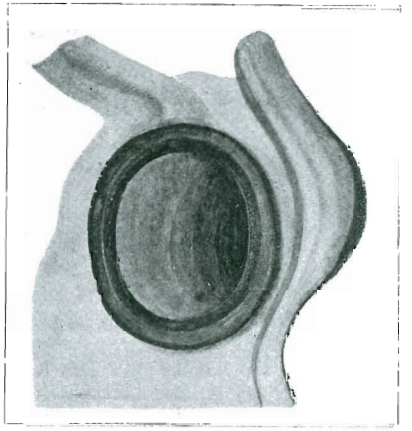
Pupæ of Cane-Beetles.

On the 22nd instant it was found that pupæ of *albohirtum* had pupated at Greenhills at depths of 10 to 24 inches. The soil was rather dry to a depth of 6 inches from the surface, although moist and very compact lower down.

Two small grubs of an undetermined coleopterous insect were located at a depth of 30 inches. Later, on the 24th instant, pupæ at Carrah, Meringa, were unearthed at depths varying from 8 to 14 inches. The soil in this case was red volcanic, similar in mechanical composition to that tested by the writer on the same estate during October 1915. In this class of land pupation apparently takes place at an average depth of about 11 inches.

Whilst at Hambledon last May it occurred to me that control of the pupal stage of *albohirtum* had never been seriously attempted, and I was interested to find that Mr. A. L. Walker had given this matter consideration, and was of opinion that fumigation with carbon bisulphide might prove beneficial in clearing up pupa-infested land before planting same. On certain areas of grub-eaten land at Meringa I have found pupæ of *albohirtum* to occur at the rate of about two per stool of cane. Assuming half these pupæ to produce female beetles, and allowing a loss of 20 per cent. of these from attacks of birds and other enemies, we shall find that the beetles arising from each acre of such infested land could produce 64,000 grubs, or enough to destroy four acres of cane.

Preliminary experiments this month with bisulphide against the pupæ have demonstrated that specimens placed in cages of compact soil will succumb to fumigation, the fumes obtaining a ready entrance through the large open spiracles. Field-work in this connection will be carried out shortly, when it remains to be seen, primarily, whether the



Diagrammatic View of one of the Spiracles of a Pupa of *Lepidoderma albohirtum* (highly magnified).

E. Jarvis, del.

lining of puddled soil spread by the grub—according to Tryon—over the walls of its subterranean pupal chamber, prior to transformation, will prove impervious to the fumes of carbon bisulphide.

Cane-Grubs Eating English Potatoes.

One hears suggestions from time to time regarding the advisability of planting English potatoes on our most badly grub-eaten cane-lands. In this regard it might be well to mention that some time back (June 1919) my attention was drawn to what proved to be a rather interesting case of white-grub attack occurring in a vegetable garden at Kamma, near Cairns. The grubs in question, which were none other than those of our greyback cane-beetle, were found to be hollowing out tubers of half-grown potatoes of variety Snowflake which had been planted in April on a plot of grayish clay-loam soil, adjoining a small block of sugar-cane. In some instances the tubers were nearly consumed, large third-stage grubs of this beetle-pest being located right inside them. This fact helps to further substantiate views held by the present writer regarding the dietary of *albohirtum* during its larval condition.

Parasite of Cane-Borer.

Steps are being taken to breed in considerable numbers the parasitic tachinid fly (*Ceromasia sphenophori*) for ultimate distribution in canefields at Gordonvale and Babinda, wherever the weevil borer may be found occurring injuriously.

September 1921.

Weather conditions during the period 27th August to 23rd September have favoured the development of our cane-beetle *Lepidoderma albohirtum*, myriads of which are at present in the pupal state, awaiting those profound changes which will eventually allow them to wing their way to the forest trees, and later on into our canefields. The rainfall here for this month has been 1·45 inches, and the average shade temperature 70·5 deg. F.

Notes on Green Muscardine Fungus.

Readings of the thermometer between the dates 13th to 31st August were particularly interesting, since they helped to illuminate certain matters relating to spore germination of the entomogenous fungus *Metarrhizium anisopliæ*. During this period of nineteen days, while our mean shade temperature was 68·6 deg. F., no less than twenty-two third-stage larvæ of *albohirtum* were killed by this fungus.

These grubs, which had been paralysed by scoliid wasps (*Campsomeris tasmaniensis* Sauss.) had lain in shallow earthern cells for about two weeks prior to the first fungus attack, so presumably must have become infested by this vegetable parasite in the field, before encountering the digger-wasps. Germination of the spores, however, did not take place until the above-mentioned temperature prevailed, although during the fortnight preceding the first outbreak of the fungus fifty or more paralysed grubs had been lying in our breeding-trays under exactly similar conditions of handling, &c. The only apparent difference was that the maximum and minimum shade temperatures during that two weeks were 75·5 deg. and 50·8 deg. F. respectively. Thus it appears likely that a slight variation (an additional 2 deg. in the average maximum and 8·7 deg. in the minimum temperatures) is sufficient to cause germination of the spores of *Metarrhizium*. It may be mentioned here that our highest mortality occurred during a mean shade temperature of 67·8 deg. F.

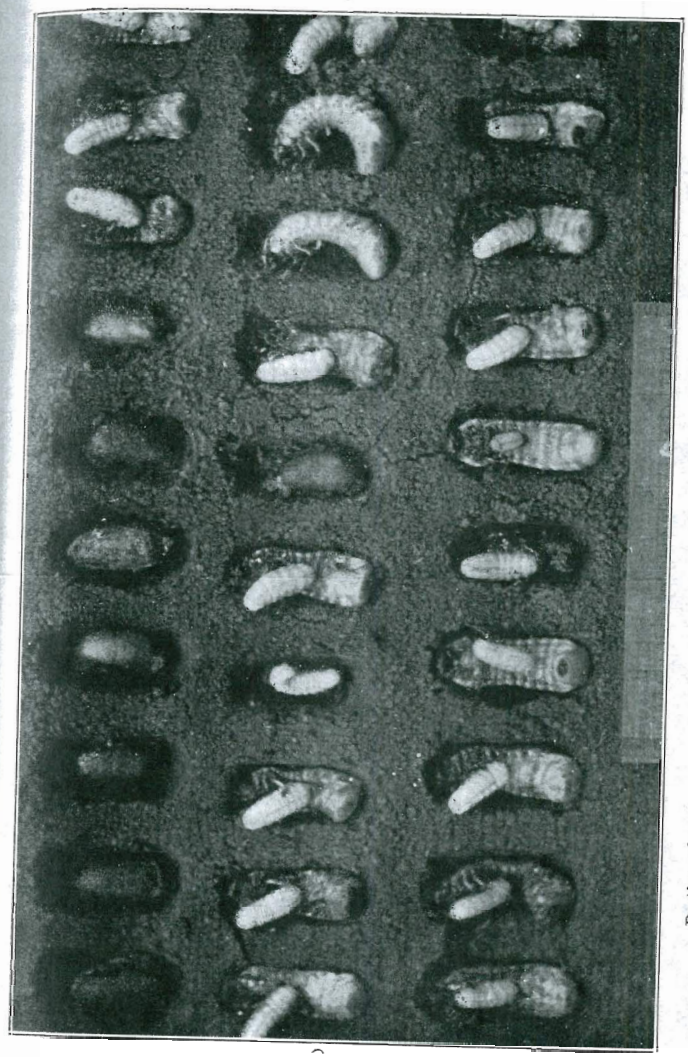
It is hoped the above-mentioned observations may prove helpful during future experimentation in connection with control work against our various cane-pests.

Breeding Digger-Wasps.

Four years ago the present writer studied the life-history and habits of two native species of Scoliidæ parasitic on grubs of our cane-beetles, and succeeded in breeding from the eggs three successive broods of wasps in the one season. The winter brood, however, which was not followed up at that time, is being investigated now, and some further interesting data have been secured.

Cool winter conditions, as might have been expected, somewhat retarded development of the various stages of these parasites. The eggs, for instance, which during summer weather hatch in three days, took from seven to ten days, or even longer; while the period occupied by the combined egg and maggot stages varied from eighteen to twenty-four days under an average shade temperature of 68 deg. F. These combined stages in the summer brood, however, during January, occupy a period of only twelve days, the average temperature at that time being much higher (about 82 deg. F.).

Plate IV.



Portion of a Breeding-tray, showing Eggs, Larvæ, and Cocoons of *Campsomeris tasmaniensis* Sauss. in concavities made in damp soil. (About half natural size.) *Photo., E. Jarvis.*

The method of handling larvæ and pupæ of digger-wasps adopted by the writer in 1918 is illustrated in the accompanying photograph of a portion of a breeding-tray stocked with rows of victimised grubs, together with egg, maggot, and cocoon stages of the parasite.

Each wasp when captured is confined in a small metal cage enclosing a cane-grub covered by about 14 cubic inches of soil, the paralysed grub being removed from each cage daily, and a healthy one supplied

in its place. The victimised hosts are at once transferred to a breeding-tray holding a layer of damp compacted soil in which numerous shallow concavities have been impressed. The life-cycle stages of the parasite, as shown by the photo., are passed in these earthern cells. The wasps are fed daily with a mixture of honey and water, and although subjected to close confinement they live about a couple of months.

From data just obtained it appears that four broods of the digger-wasps *Campsomeris tasmaniensis* and *radula* may occur every year. Those giving rise to what we may term the first or spring brood commence to oviposit towards the end of September, the earliest eggs having been obtained on the 22nd and 27th of that month. Egg-laying, however, becomes general towards the end of October, and wasps finally emerge from this brood about the middle of December.

The period occupied by the summer brood or second generation extends approximately from middle of December to middle of February. The autumn or third generation originates from wasps emerging throughout March, oviposition occurring from about the end of that month to beginning of May, and flighting of the adult wasps from May to August. Eggs producing the winter brood are laid in June and July. At present we have only the cocoons of this brood, from which wasps of the fourth generation are expected to emerge in a week or so.

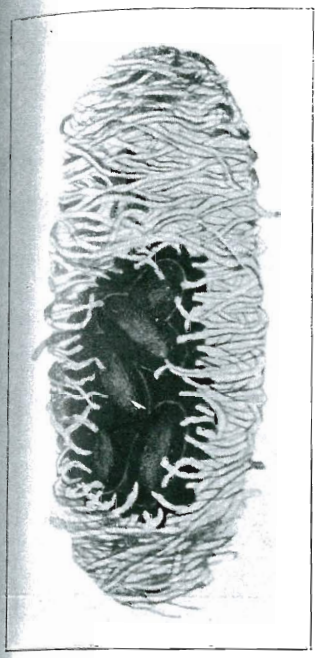
Additional details with regard to technique employed here in this connection need not be given at present; but it may be of interest to state that, in the event of our deciding to introduce wasp-parasites into Queensland from other countries, we shall be in a position to handle them during transit in a manner best calculated to keep them alive and ensure successful introduction.

The Cane-Borer and its Parasite.

A trip was taken to Babinda on the 31st August and again on 19th September, with the object of securing specimens of tachinid flies (*Ceromasia sphenophori*). Thanks to the courtesy of Mr. A. McColl, manager of Babinda Central Mill, I was enabled to visit Meriwinni, Mooliba, and other districts, in company with one of the cane inspectors, Mr. C. Robinson.

As a result of our search a number of tachinid flies were captured, with which to commence breeding experiments at Meringa. These were found resting on loaded trucks of cane, at Mooliba and in the mill yard. Pupæ of the parasite were also located in borer-infested cane from several farms, so that it should not be a difficult matter to breed hundreds of specimens of this tachinid for future liberation in districts affected by the beetle-borer around Gordonvale, &c. Growers troubled with this borer are asked to forward samples of infested stalks to Meringa Railway Station. It would not be much trouble to cut a sackful of badly bored cane; and such consignments would be of considerable value to us, and receive due acknowledgment.

The fact of this parasite being in evidence at present on farms suffering greatly from borer attack indicates either that its work is of little or no avail or is being constantly checked in some way. Burning the trash, although helpful in controlling the weevils, destroys also its parasites and predatory enemies. Continued indiscriminate burning



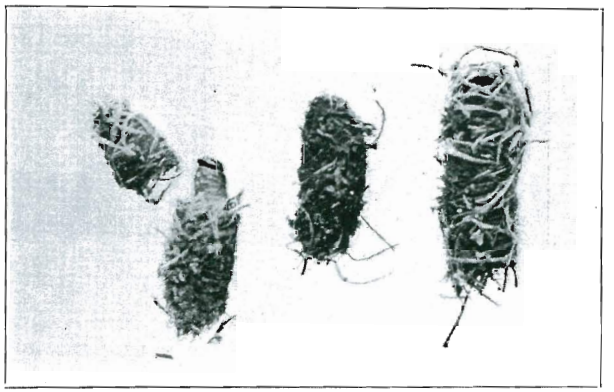
COCOON OF WEEVIL BORER OF CANE (DIAGRAMMATIC DRAWING SHOWING SMALL COCOONS OF TACHINID FLY PARASITE INSIDE THAT OF BORER).

E. Jarvis, del.

would, before long, probably result in disappearance of the tachinid fly from such localities. A small patch of bored cane should accordingly, when possible, be reserved in some obscure quarter as breeding-ground for the fly, and this should not be burnt.

Bait-collecting has achieved good results in times past; and since this method of control is within reach of every grower, and affords a means of materially checking the ravages of this pest, its merits should not be altogether overlooked. These baits consist, as most growers are aware, merely of pieces of split cane about eighteen inches long, which are placed in heaps, of from ten to twenty pieces, near or among the cane-plants. As a result of rather extensive experimentation in Fiji, it was seen that molasses smeared on the baits did not make them more attractive, and that baits cut from decomposing cane attracted far more borers than those consisting of fresh cane. It appears also that collections made every second day from heaps placed near the border of a plantation gave better results than frequent collections (three times a day) derived from single baits laid throughout the field.

With regard to the question of collecting weevil-borers, I may mention that 3,600 specimens weigh one pound, and that this number of beetles are able to destroy at least

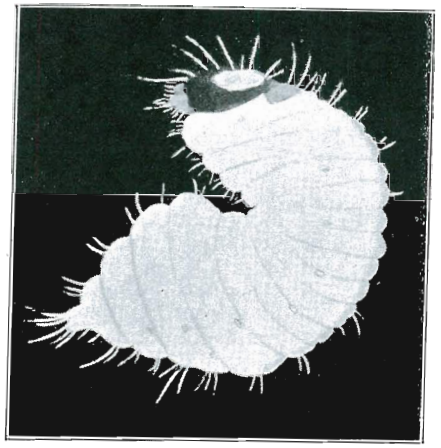


COCOONS OF WEEVIL BORER (NATURAL SIZE).

Photo., W. C. Dormer.

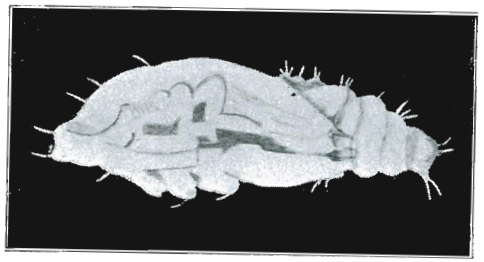
5 acres of cane. In cases of severe infestation it would, I think, be well worth our while to collect them. By laying bait-traps immediately after cutting the crop, large numbers can be caught at little expense, as the beetles dislodged from the cane usually concentrate on these baits for many days after the crop has been cut.

Varicty of Cane Resistant to Beetle-Borer.—Some plants of the cane H 146, a variety which is said to be very resistant to *Rhabdocnemis*



LARVA OF THE BEETLE-BORER OF CANE (HIGHLY MAGNIFIED).
E. Jarvis, del.

obscura Boisd., have just been received from the General Superintendent, and a grower at Gordonvale has been kind enough to plant them among a patch of D 1135, on land usually favoured by this pest. It will be interesting to note, later on, whether the borer-beetle attacks the surrounding cane in preference to the variety in question.



PUPA OF THE BEETLE-BORER OF CANE
(HIGHLY MAGNIFIED).
E. Jarvis, del.

October 1921.

TEMPERATURE AFFECTS EMERGENCE OF CANE-BEETLES.

The warmth experienced here during the past few weeks has raised the soil temperature, and so favoured an early transformation of the pupæ of *Lepidoderma albohirtum* to the imago or beetle condition.

The average shade heat between the dates 10th to 17th October was 84 deg. F., a temperature exceeding that which normally obtains during our summer months. Such conditions being accompanied by a precipitation of 2·74 inches of rain, it seemed likely that about 50 per cent. of the beetles might make an early emergence. Apparently, however, this heat has not been sufficient to arouse them from a torpid state, as up to the present (28th October) no decided emergence has taken place.

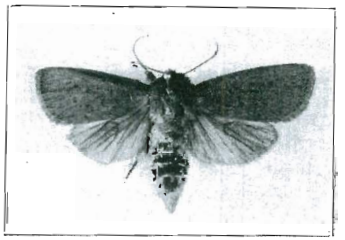
The past winter having been somewhat cooler than usual, it is quite possible that the beetles may not appear until early in November.

CONDITIONS AT GREENHILLS.

The cane on this estate, which at present consists of about 160 acres of ratoon and 90 of plant cane, is making splendid growth, the September planting being already about 3 feet high. Mr. Hoelscher, the manager there, is experimenting against the grub by burying a layer of trash directly underneath the cane, the trash being first placed in a trench and covered by a layer of soil, on top of which the sets are then planted in the usual manner. Several rows have been treated in this way and a number of adjoining rows left as a check-plot. About 600 acres are to be placed under Mauritius beans, one-third of this area having already been sown. The whole crop will be ploughed under in due course, and followed by cane to be planted early next year, when it is hoped by Mr. Hoelscher that the grubs may feed on the humus supplied by this green manure, and leave the cane alone. At present very few grubs of any sort are showing up in the furrows, and no beetles have been noticed.

LARGE MOTH-BORER OF CANE.

This insect, which is sometimes confused with the beetle-borer of cane, is giving trouble just now in the Lower Burdekin and Bundaberg districts. Growers writing from Rita Island state: "This pest has gradually become worse, until this season, when areas in one patch have been destroyed." "They are very bad on my farm this year, attacking the young plant-cane as soon as it is out of the ground; they clean out patches completely. They are also bad on the adjoining farms." The larva of this moth-borer (*Phragmatiphila truncata* Walk.) does not in the least resemble that of the beetle-borer; the former being a slender caterpillar about 1½ inches long, while the latter is a plump maggot-shaped grub (*see* p. 62).



LARGE MOTH-BORER
(*Phragmatiphila truncata* Walk.)
(nat. size).
Photo., Dept. Agriculture.

This moth-borer usually attacks young ratoons and plant-cane, killing the central unfolding leaves, which quickly wilt and turn brown, such plants finally exhibiting what is termed "dead-heart." When occurring in big cane it is generally found boring the top of the stalk.

The beetle-borer, on the other hand, seldom attacks very young shoots, and when infesting mature cane is most often seen tunnelling the basal portion.

The large moth-borer is common here in canefields but appears to be effectively controlled by natural enemies, amongst which the well-known ant *Pheidole megacephala* may be considered an important factor. The writer has also bred, from parasitized caterpillars found in bored cane at Pyramid, a tachinid fly and a braconid wasp parasite, *Apanteles nonagriæ* Oll. The latter insect has previously been described as a parasite of this moth-borer in New South Wales, but has not, I believe, been recorded hitherto from Queensland.

Judging by reports to hand regarding the mode of attack manifested by this pest on the Lower Burdekin, it appears likely that two at least of its above-mentioned natural enemies do not occur there. We intend, therefore, collecting specimens of the parasites in question at Pyramid, and, upon obtaining same, breeding them here until getting a sufficient number to convey to Rita Island for liberation on plantations where this borer happens to be troublesome.

A special breeding-cage is being constructed for this work (including about 90 cubic feet of space) which will contain cane-plants growing naturally in soil about 9 inches deep, in order to secure ideal conditions for breeding these parasites.

Control of the Adult Beetle.

One of the phases of control we propose investigating this coming season is that of poisoning the adult beetles before they have had time to oviposit. Experimentation in this connection will include field as well as laboratory work. Beetles will be confined separately in cages containing favourite food-plants which have been sprayed with various poisons, while feeding-trees in the forest will also be treated with similar arsenical solutions.

Preliminary experiments of this nature were initiated by the writer in 1915 ("Australian Sugar Journal," vol. vii., p. 62), when it was found that arsenate of lead-molasses solution proved fatal after nine days, during which time 69 beetles devoured 32 square inches of the poisoned leaves (about ½ sq. in. to each insect.) This spray, although slow in taking effect, would, nevertheless, be serviceable if administered to beetles directly they appear on the trees, as a period of about fourteen days elapses between emergence and oviposition. It is hoped, however, to discover an insecticide this season that will prove fatal in a week or less.

It may be mentioned in this connection that amongst the numerous native food-plants of *albohirtum* there are two which invariably attract great numbers of beetles—viz., *Ficus pilosa* and *F. nesophila*. Growers who intend to collect beetles invading their canefields could not do better than plant clumps of three or four of these fig-trees on headlands or among their cane on roadways at convenient distances apart.

Such trap-trees should be pruned occasionally to keep the heads low and spreading; and could either be collected from during the flighting season or sprayed with some suitable arsenical upon the first appearance of the beetles. Cuttings were taken by the writer from both these figs a few months back, in order to see if they could be easily propagated, some of them being root-grafted in the ordinary way and the remainder planted without special treatment. The latter method proved the more successful, and we had no difficulty in striking a large percentage of

these cuttings. Next season we hope to be in a position to supply young rooted trees of both these figs, free of cost, to any growers who may care to plant them.

Breeding Beetle-Borer Parasites.

Examination on the 25th instant of cane-sticks that had been artificially stocked with grubs of the weevil-borer, and planted on 14th September in a large breeding-cage, revealed the presence of pupæ of the tachinid fly in each stick (*see* illustration on p. 61). These fly-pupæ, which resulted from maggots deposited by flies collected and brought by the writer from Babinda on 22nd September, will produce parasites about the end of this month (October), and constitute our first brood for the present season. The life-cycle, from larva to perfect insect, has taken in the present instance about forty days, but successive broods should come through during the hot weather in about five weeks. Flies forming the first brood will be used for breeding from, but we hope to have specimens available for distribution before next season's cane is old enough to sustain serious injury from borer attack.

Fumigating Pupæ of Cane-Beetles.

In my August report (p. 57) allusion was made to successful laboratory experiments against the pupæ of *albohirtum*, our common greyback cane-beetle. Preliminary field tests conducted during September demonstrated that fumes of carbon bisulphide are able to penetrate the walls of the pupal chamber, and injections made at a depth of 8 inches proved fatal to pupæ lying at an average depth of 11 inches. Owing to prolonged wet weather these experiments had to be discontinued. This matter will be followed up next season with a view to securing further data.

Mulgrave not Collecting Beetles.

At a meeting of the Cairns Cane-growers' Association, held at Gordonvale on the 20th instant, the Mulgrave growers decided they would not collect beetles or grubs this season. Such action, or rather inaction, is very regrettable, and it is to be feared that in the event of dry weather obtaining during the period occupied by the third stage of *albohirtum* many growers may suffer serious losses. The emergence of this beetle last season was the biggest yet observed by the writer (during the past seven years). Fortunately, however, prolonged wet conditions promoted rapid growth, and in many cases the cane here had attained a good length before the grubs became large enough to do much damage. Again, later on, during the critical period, showers and cloudy days kept the tops green, while sticks that had fallen were able to root afresh and keep alive until crushing time. Judging from past experience in this and in other countries, we may reasonably expect cane-beetles to appear this season in very great numbers.

November 1921.

Emergence of Cane-Beetles.

As a result of showery weather—between the dates 26th and 31st October—which gave a precipitation of 1·40 inches, greyback beetles emerged rather freely from volcanic and other soils around Gordonvale where pupation had taken place within reach of the plough.

Pupæ lying in such situations probably feel the effect of solar warmth earlier than those located at greater depths, or in heavy clay-loam lands. At Highleigh the first appearance of this pest attracted some attention, the beetles being very numerous on various food-plants bordering the main road, and congregating in thousands on some large fig-trees (*Ficus benjamini*) against the residence of Mr. J. Cannon.

Native food-plants found to be mostly affected in this district on 11th November were the Moreton Bay ash (*Eucalyptus tesselaris*) and one of the rough-leaved figs (*Ficus opposita*); the latter species, however, being, as a rule, seldom eaten unless far removed from other more favoured feeding-trees.

Twenty-nine beetles were collected from one of many small bushes of eucalyptus about 5 feet high, growing on a roadway in the midst of cane-land, 15 of these being male and 14 female specimens.

Again, 48 beetles collected earlier, at random, from gums around the laboratory close to canefields, between the dates 4th and 7th November, and placed separately in cages for experimental purposes, were found, when examined after death, to consist of 13 males and 35 females. The above figures substantiate data already published by the present writer in 1915 ("Australian Sugar Journal," vol. vi., p. 891), and shows the importance of collecting beetles from feeding-trees close to headlands during the three weeks following emergence, before egg-laying commences.

On 18th November we had an additional fall of 1·36 inches of rain, and three days later a second lot of greybacks found their way to the surface. On one plantation of first ratoons at Meringa, for instance, as many as five beetles emerged from beneath each stool of cane, which means that the beetles arising from every acre of this land were sufficient to produce, later on, enough grubs to destroy fully nine acres of cane.

Light-Traps.

Some rather interesting observations were made during several evenings between the 4th to 26th November regarding the tropic reaction of *albohirtum* to artificial light. The trap employed was a simplification of that designed and figured by the writer in 1916 ("Australian Sugar Journal," vol. vii., p. 903); and in the present instance consisted of an empty kerosene case fitted with side platforms and vertical barriers of galvanised iron, the latter being glazed where coming opposite the burner of an acetylene lamp of 21 litres.

Few beetles were caught early in the month, as the moon happened to be nearing the end of the second quarter, and, moreover, temperatures between the hours of 8 and 9 p.m., while beetles were on the wing, were rather low. During these few nights it was noticed that greybacks when approaching the trap were inclined to circle around it, influenced probably by the moonlight; and that, if failing after several short flights to reach their objective, ceased to be attracted, and suddenly became motionless. When this stage had been reached a bright flame placed two inches from the head of the beetle did not affect it in the least, clearly indicating a cessation of positive phototropic reaction for the time being. On 26th November, from 8 to 9 p.m. four specimens of the so-called "Christmas Beetle" (*Anoplognathus boisduvali* Bois.) entered the trap, and only fourteen greybacks, the temperature having dropped in the course of an hour from 82 to 72 deg. F.

Beetles belonging to the second emergence will commence invasion of our canefields about 10th December, when we hope to secure further data on the influence exercised at that time by artificial light on male specimens and egg-laden females.

Plate V.

EXPERIMENTATION WITH AROMAS AGAINST THE "GREYBACK" CANE-BEETLE.
Note bait-traps hung among branches of feeding-tree (*Ficus pilosa*).

Photo., E. Jarvis.

Attractive Aromas for Controlling Cane-Beetles.

This line of work has consisted in preparation and exposure in the field and feeding-trees during night-time of various odours, one of which, it is hoped, may be found attractive to the adult beetles.

The principal substances experimented with have been—(1) those considered likely to prove palatable as food; (2) chemical compounds possessing aromas resembling those emanating from the chief food-plants of the beetle; and (3) miscellaneous odours such as arise from decaying vegetation, soils, roots, &c. This work is of decided importance, as, in the event of any success being obtained, it would then be a simple matter to design suitable traps, which, when baited with the attractive substance, could be so arranged in a canefield as to lure to destruction from different directions most of the invading beetles.

It may be of interest to state that my hopes regarding this form of control were stimulated after making a microscopical examination of the antennæ of *albohirtum*, our common greyback cane-beetle. The sense of smell in insects is known to reside principally in these organs, and in the case of the beetle under consideration the laminæ or plates composing the antennal club are very highly specialised, the surface of each of the four plates in that of the female being closely covered with many thousands of minute pits or pori, each containing a central rod connected with the olfactory nerve. I found these pits to occur in even greater numbers in the club of the male, which is provided with an additional plate for their accommodation. Doubtless it is this keenness of scent that enables our cane-beetle to locate from a distance certain favourite feeding-trees. In the event of any grower chancing to notice greyback beetles assembling in numbers on or around objects other than feeding-trees, in such manner as to suggest their having been attracted, it would be advisable to communicate at once with the entomologist, either by wire or 'phone (Tel. 95, Gordonvale).

The accompanying photographs illustrate an experiment with aromas exposed in traps hung among the branches of *Ficus pilosa*.

Eggs of Beetle Killed by Fumigation.

On 10th November eggs of the greyback cockchafer were obtained from caged females in our insectary, and three days later placed in flower-pots of moist soil and fumigated with carbon bisulphide.

Two eggs were put in the bottom of each pot in a small cell roofed by a compacted piece of earth, and then covered with from 130 to 280 cubic inches of soil. The bisulphide was then administered at distances varying from 4½ to 8 inches, the dose in each case being 2 drachms (¼-oz.). In field practice, if a couple of injections were given to each stool of cane, the above dose works out at about one drum per acre.

Twenty-four hours after treatment the eggs were taken from each pot and placed in glass cells, so that developments might be closely observed. Little change was apparent for two days, except that the treated eggs darkened slightly and did not increase in size; but on the 25th November (three days after fumigation) the control eggs had become noticeably larger, and remained creamy white, while the fumigated specimens were dark brown and partially covered by mould.

By 1st December all that remained of the latter was the shrivelled egg-shells (chorion), each lying in the midst of a patch of mould on the soil; while the untreated eggs—submitted to precisely similar conditions of moisture and temperature—were perfectly normal, free from any signs of mould, and had developed to nearly a quarter of an inch in diameter. This experiment was repeated on 24th November, with varying doses of bisulphide, the same results being obtained in every case. We may safely conclude from the above details that such fumigation kills the eggs in a few hours, although, naturally, mould does not appear on the chorion until the internal albuminous matter commences to decompose. (*See* illustration on p. 40.)

This discovery is not without value, since the knowledge gained enables us to start fumigation, if desired, as soon as all the eggs have been deposited; thus giving more time in which to get over a big plantation while the cane is still small.

Trap-Trees for Killing Beetles.

Continuing research work in this connection, initiated by the writer in 1915 (*see* p. 12), five sets of experiments have been conducted between the dates 5th November and 2nd December, comprising eighty-nine cages containing leaves sprayed with various arsenical solutions. The data secured will be published next month.

Parasite of Moth-Borer.

Two years ago (November 1919) the present writer was fortunate in breeding a braconid wasp (*Apanteles nonagriæ* Oll.) from our large moth-borer of cane (*Phragmatiphila truncata* Walk.).

This parasite, which was first recorded by Oliff in 1893, is thought to be of great value in New South Wales, where it helps to control the ravages of the same moth-borer. It had not, however, been previously recorded from Queensland, so that its presence at Pyramid in 1919 is of considerable economic interest.

As mentioned in my October report (p. 64), we were hoping to obtain specimens of this useful parasite again, so as to breed numbers for distribution in the Lower Burdekin. I am glad to be able to state that our search has been successful, and a number of specimens have quite recently been bred from ratoons collected at Banna, near Gordonvale.

December 1921.

During the past month the time has been very fully occupied in experimentation affecting the adult or imago form of our greyback cockchafer. Unfortunately, this important phase of its life-cycle lasts only a couple of months—viz., during the flighting period—whereas the grub stage admits of investigation during about six months of the year.

The wet season set in here on the evening of 19th instant and by midday on the 21st 7·18 inches of rain had fallen at Meringa, thus putting a stop for the time being to field experiments and soil fumigation.

Experiments with Deterrents.

Our plots at "Carrah" were treated between 12th November and 8th December in order to allow for beetles emerging at beginning of November, and for a second emergence on the 18th of that month. The various insecticidal substances used, with a view to inducing beetles to avoid the treated areas, were coal-tar, naphthalene, chloride of lime, tobacco dust, and carbolineum emulsion; each plot being one-eighth of an acre, and separated by a control plot. To avoid labour involved in emulsifying and spraying the tar, it was prepared by mixing the quantity needed—viz., 2 gallons = 16 gallons per acre—with five kerosene tins full of sifted soil, so that it could be easily sprinkled either by hand or machine, on each side of and between the stools of cane in a strip about three feet wide.

When examined twelve days later (0·15 inches of rain having fallen during the interval), the tarry odour was quite pronounced, and even after twenty-six days it was still perceptible, although perhaps not sufficiently so to be repellent. The chloride of lime, which was also mixed with soil and applied at the rate of 160 lb. to the acre, maintained its odour nearly a week, but lost it about nine days after application. The naphthalene was administered at the rate of 120 lb. per acre, and kept its repellent properties longer than the lime; while the carbolineum emulsion did not keep its odour more than a few days. Tobacco dust applied at the rate of 96 lb. retained its odour for some days after application. It will be interesting to note later on whether any of these deterrents have induced egg-laden female beetles to oviposit elsewhere.

Poisoning Cane-Beetles.

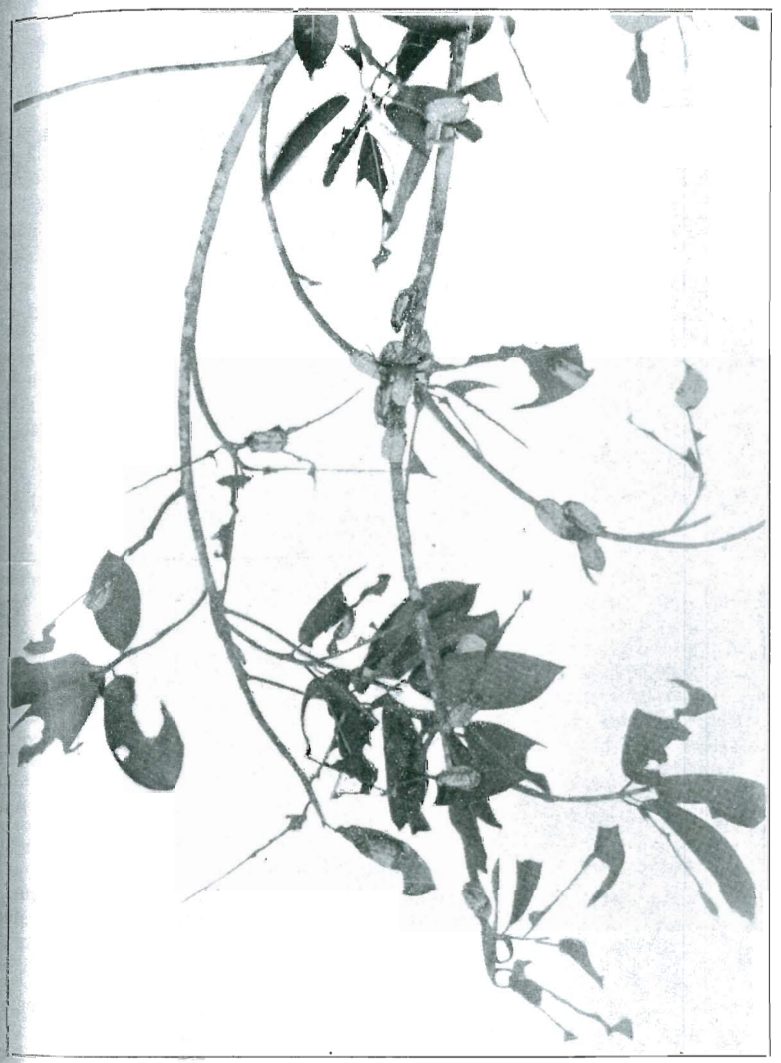
As mentioned last month, five sets of experiments have been conducted this season, comprising eighty-nine cages containing leaves sprayed with various arsenical solutions.

The results obtained, although not altogether conclusive, were sufficiently encouraging to warrant further experimentation along similar lines next year. One point of importance observed was the fact that beetles to be experimented with should be captured directly they emerge, and before they start feeding. After being four or five days on the trees they cease feeding, and practically eat little or nothing during the remainder of their aerial existence. For instance, out of fifteen beetles collected on 2nd December (nine days after emergence) about 50 per cent. did not live more than a week; and during the course of this experiment only one beetle out of this number touched the fresh fig-leaves placed in its cage.

Those used for the first experiment were captured on 5th November, about four days after emerging from the soil, but even then the majority had ceased feeding, as only eight out of thirty touched the leaves placed in their cages. The first beetles to die, however, were those that had eaten portions of the poisoned leaves.

Paris green 1 lb., lime 1½ lb., in 8 gallons water, proved fatal from four to seven days after feeding; while arsenate of lead took nine days. About 50 per cent. of these beetles died just a fortnight after capture, the last succumbing after twenty-four days. The beetles that lived longest (sixteen to twenty-four days) were those that took no food whatever. The specimens that fed were four control beetles, and a similar number from treated cages.

Plate VI.



GREYBACK CANE-BEETLES FEEDING ON FOLIAGE OF FICUS PILOSA.

Photo., E. Jarvis.

In an experiment conducted 22nd November, it was found that confined specimens of *albohirtum* would feed indifferently either on Moreton Bay ash (*Eucalyptus tesselaris*) or the tar-tree (*Semecarpus australasiæ*), when leaves of both species were placed together in the cages.

I have previously mentioned (p. 13) that this cane-beetle does not, like some insects, exhibit a keen sense of discrimination in the choice of food, but, on the contrary, appears indifferent as to its flavour, being as ready to devour leaves sprayed with poisons as untreated foliage.

Parasite of Moth-Borer.

It will be of interest to mention that success has attended our efforts to breed and propagate the braconid wasp, which, as mentioned last month, is an insect enemy of the moth-borer of cane in New South Wales, where it is credited by Oliff with being a parasite of great economic importance. I am of opinion that the control of our large moth-borer in the Cairns district is due mainly to the activities of this tiny wasp.

The specimens bred by us this month from ratoons collected at Banna were confined in suitable cages with borer caterpillars on 5th December, and, having been parasitized, produced broods of wasps three weeks later (25th December). In view of the fact that each of these parasites is able to lay nearly 100 eggs (our highest record here at present being 93), and, moreover, has a life-cycle of only three weeks, it is not surprising that moth-borer attack should be confined here to a few localities, where it is seldom noticed except early in the season, and very seldom assumes serious proportions. The parasite in question, *Apanteles nonagriæ* Oll., is a minute black wasp no bigger than a sandfly, and having thread-like antennæ or feelers, which in the male are much longer than the body, and noticeably longer than those of the opposite sex. The female punctures the caterpillar by means of a special piercing instrument or ovipositor, and deposits eggs inside it, these in due course producing maggots that commence at once to feed on the internal tissues. The larval stage occupies about fourteen days, after which the maggots leave the body of their host, and, remaining together, spin white, egg-like, silken cocoons, which are usually concealed behind some dead leaf-sheath, but sometimes located inside the tunnel in the bored ratoon.

These cocoons, which occur side by side in a flattened mass, and are about $\frac{3}{16}$ inch long, with rounded ends, finally produce wasps a few days later.

Beetle-Borer Parasite.

Bred specimens of the tachinid-fly parasite of *Rhabdocnemis obscurus*, the well-known borer of cane, continue to emerge freely in our insectary from cane-sticks artificially stocked with beetle-grubs during November.

Numbers of these parasites have been liberated this month (December) on plantations at Riverstone, and on land subject to borer on the banks of the Mulgrave River at Gordonvale. Several letters have been received from the Innisfail and Babinda districts, asking for tachinid flies. In order that all requests may be met, we intend to continue the breeding of this insect during January and February.

Beetles as Food.

A sample of beetle-meal prepared from our greyback cockchafer has been submitted this month for analysis, and may prove to be a valuable food for poultry. The Curator of the Zoological Gardens in Sydney has tried for some years past to obtain meal of this nature for feeding

insectivorous birds, and is prepared to offer a good price if the analysis should prove favourable. In the present instance the beetles collected were killed with hot water and dried at once in a simple home-made oven of galvanised iron. The bodies were then reduced to meal by being passed through an ordinary corn-crusher.

It might be of interest to mention that a manure is prepared from the bodies of the European cockchafer (*Melolontha melolontha*). Guenaux states that this "is equal to that of the best manure as regards phosphoric acid and potash, and is eight times richer in nitrogen. One hundred pounds of beetles are therefore," he remarks, "equal to 800 lb. of manure." In view of this statement it seems probable that the 22 tons of beetles collected in the Cairns district during 1914 might have been turned to profitable account. In the event of collecting being again taken up here it would be advisable to look into this matter of the manurial value of our cane-beetle, and if possible defray in this way part of the expense of collecting.

January 1922.

During the course of the past month our time has been largely occupied with very necessary laboratory work in connection with certain methods of control to be directed this season against second and third stage grubs of the cane-beetle *Lepidoderma albohirtum*. Initial experiments with miscellaneous preparations, conducted by the writer last November, led to the discovery of two substances that appear well worthy of investigation. These will be thoroughly tested, and the results reported later on.

Our Fight against Ants and Vegetable Parasites.

Allusion has been made from time to time in these reports to a small black ant (*Pheidole megacephala*) which occurs freely in most canefields, where it does good service by destroying caterpillars of moth-borers, &c. In the laboratory and insectary, however, where its presence is anything but desirable, it proves a continual source of annoyance. In one of our large cages, for example (*see* Plate VII), built recently for rearing tachinid-fly parasites, the legs were stood as usual in pans of water, and, before planting the canes containing borer grubs, the soil (about 36 cubic feet) was twice fumigated with carbon bisulphide, and the surface afterwards treated with boiling water. This answered for a time only, until the swarming period occurred, when a few of the winged female ants flew unobserved on to the sides of the cage, and crawling between the boards invaded the forbidden soil, forming colonies consisting of thousands of individuals, which a week or so later were found to have taken complete possession, and to be actually nesting in some of the bored canes.

This voracious little ant will devour alike leaf-eating caterpillars and other insects, household foodstuffs of many kinds, or even newly hatched featherless birds, &c., &c. It is said to be a native of Mauritius, but is now of world-wide distribution.

In spite of such drawbacks, fully 200 tachinid flies, intended for liberation at Babinda and South Johnstone, emerged in this cage towards the end of December. Unfortunately, however, a spell of wet weather lasting about a fortnight set in at this time, establishing climatic conditions eminently favourable to the development of a certain fungus (*Empusa* sp.) which straightway attacked these parasites.

PLATE VII.

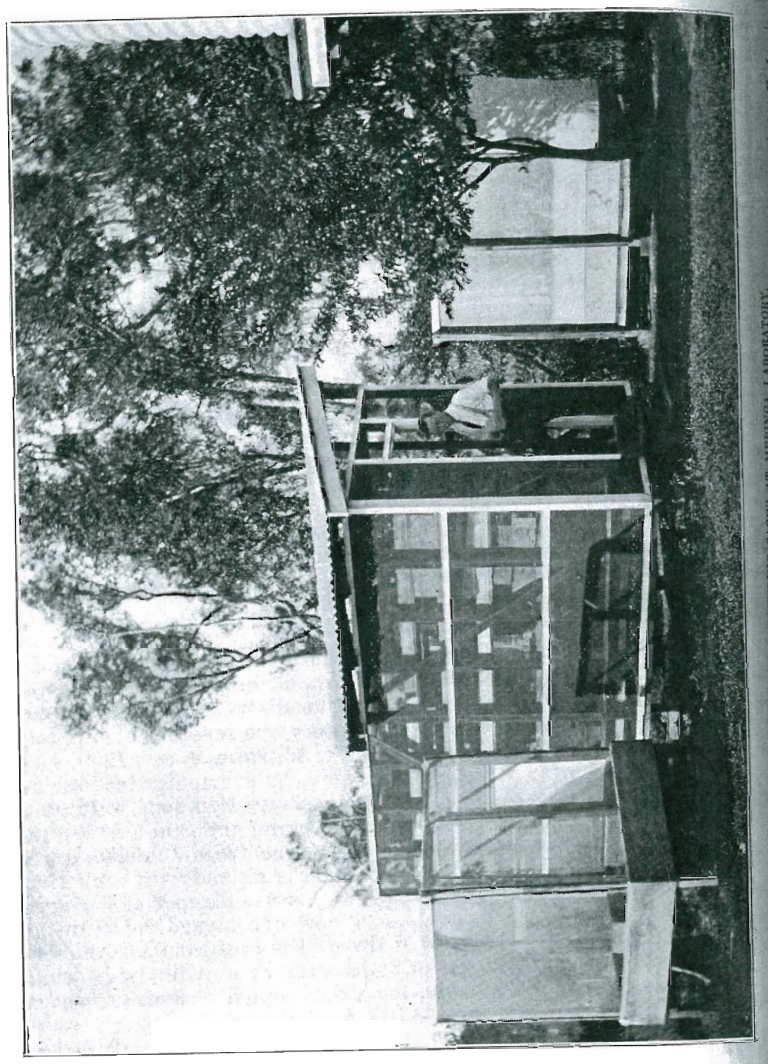


Photo., E. Jarvis.

INSECTARY AND BREEDING-CAGES AT MEERINGA LABORATORY.

Most of us have occasionally noticed house-flies when killed by *Empusa muscæ* sticking, as if glued, to a window-pane, with wings and legs fully extended, and the body swollen, yellowish, and mouldy-looking. Tachinid flies exhibiting this characteristic appearance were found each day adhering to the sides of the cage (on the mosquito netting), and to leaves of shade-plants, &c. In a week or less this vegetable parasite had accounted for more than 50 per cent. of the flies.

This entomogenous fungus doubtless acts as a controlling factor in canefields during the wet season, probably affecting broods of flies emerging between December and February.

FUMIGATING CANE-GRUBS.

The question of machine treatment for administering bisulphide of carbon in canefields is still receiving consideration. Mr. Dawson's machine was submitted to a field test last November, but did not prove satisfactory. A continuous flow of bisulphide was administered from the outer side of an iron tooth drawn through the soil. In the first trial no provision was made for filling in the furrow left by this tooth, or for consolidating the soil above the line of injection by some downward pressure. The fumigant, being left in loosened-up earth which was dry overhead, doubtless escaped upwards during the ordinary course of evaporation of the moisture. Mr. Dawson, however, deserves credit for being the first, I believe, to attempt machine treatment for the fumigation of cane-grubs; such pioneering work is always commendable.

Some of the growers here are applying bisulphide this season by means of the "Danks Injector." The following hints on the use of this fumigant may, therefore, be found useful:—

(1) Injections in light soils among young plant-cane should not be made closer than about six inches from plants, and eighteen inches apart; and need only be applied on one side of a line of stools.

(2) Injections made during high temperatures, or when the soil lacks sufficient moisture, may injure or kill very young cane.

(3) Fumigation should not be carried out at a time when the porosity of the ground is closed by an excess of moisture, as happens immediately after a soaking downpour.

(4) In red volcanic soil the ground is generally open, and in good condition for treatment, a few days after heavy rain, as the surface, being then caked, prevents escape of the bisulphide fumes, and all that is necessary is to close the holes made by injections.

(5) Sandy soils are in fair condition for fumigation after a light rain.

(6) Do not cultivate the soil for a week or so after treatment.

(7) An application of carbon bisulphide greatly improves exhausted soils, and destroys certain injurious bacteria.

(8) Before application examine the roots of a few stools to find at what depth the grubs are working, and then arrange for injections to be made an inch or two above them.

LONGEVITY OF THE GREYBACK COCKCHAFER.

In view of the fact that growers here appear to be uncertain regarding the length of life of our principal cane-beetle (*Lepidoderma albohirtum*), it may be well to mention that recent investigations by Labitte, who has made a special study of the longevity of beetles, has supplied us with interesting data in this connection. In his table giving the maximum period of existence for no less than forty-eight species

of Coleoptera in captivity, we find that a tenebrionid beetle (*Blaps gigas*) lived 3,349 days, the lives of nine other species being found to vary from 1,005 to 1,219 days. An additional thirty-three beetles, belonging to different genera, had a maximum longevity of from 114 to 989, while the shortest life-period among all these forty-eight beetles was that of the common European cockchafer (*Melolontha melolontha*), an insect closely allied to our own cane-beetle *albohirtum*, and of similar habits, which lived only 31 days. During the past seven years I have repeatedly found that captured specimens of *albohirtum*, taken just after emergence from the soil, do not live longer than from three to four weeks, even when kept under the most favourable conditions. It is interesting to note that the period of longevity in our own species of cockchafer happens to coincide with that of the European species.

A New Digger-Wasp Parasite of the Greyback Cane-Beetle.

I have pleasure in recording *Scolia formosa* Guer. as being parasitic on grubs of our cane-beetle *Lepidoderma albohirtum* Waterh.

This discovery was made in May 1920, when the present writer, chancing to obtain a female of this handsome digger-wasp at Gordonvale, succeeded in working out its life-history. The specimen, which lived just eight weeks in confinement, laid 24 eggs on grubs of *albohirtum*, but refused to oviposit on those of *Lepidiota frenchi* Blackb. Only eleven cocoons were obtained, the remaining eggs having been destroyed by mites and other enemies. The life-cycle occupied 108 days, 3 being taken up by the egg stage, 11 by the maggot condition, and 94 by the cocoon stage. *Scolia formosa*, which is about the size of our common digger-wasp *Campsomeris tasmaniensis* Sauss., is mostly black, broadly banded on the abdomen with reddish orange; while the thorax, legs, and head are rather densely clothed with reddish hairs. The egg differs from that of *Campsomeris* in being shorter and proportionately broader. The larva, when about $\frac{3}{16}$ inch long, is shining, smooth, pale greenish yellow.

Scolia formosa is rather a rarity in this district. In view of the fact of its occurrence in other countries it may have acquired a habit of frequenting quite a number of different honey-bearing flowers, so that possibly our "feather-horn" beetle (*Macrosiagon pictipennis* Lea), which is hyperparasitic on *Campsomeris* wasps, may find *formosa* a readily accessible host.

February 1922.

Fumigation of Cane Grubs.

Intense heat during February, accompanied by abundant rain at intervals, has somewhat interfered with outside work, although, on the whole, laboratory experiments give promise of success in the field later on.

As already pointed out in 1915 (p. 15), one of the best forms of control against the grub stage consists (in the writer's opinion) of the application to cane sets or furrows, at planting time, of some inexpensive deterrent sufficiently obnoxious and durable to protect a limited area containing the main roots from invasion during the growing period.

Another promising remedy is fumigation of the soil with some gas that, while deadly to animal life, is harmless to cane-plants, and possesses

manurial value. Fumigation with carbon bisulphide, for instance, would come under the latter remedial method, and therefore some attention has been given during the last couple of months to field experimentation with this well-known fumigant.

With regard to the former method of control by means of obnoxious repellents, this matter is being closely studied, several chemical preparations having been tested up to the present with varying measures of success. We are working towards the discovery of a substance possessing an odour of such durability as to allow of its influence being exercised in the soil throughout a period of three months or longer. If put into the drills along with cane-sets when planting, say, in September, a substance of this nature would have time to render the soil around cane-stools sufficiently disagreeable to probably act as a repellent to beetles entering the field to oviposit during November and December. One of the preparations being tested here at present, consisting of a combination of certain chemicals, is not only repellent but possesses the additional advantage of being fatal to animal life. Grubs confined in cages holding about 40 cubic inches of soil that had been treated with a small injection of this fumigant were semi-paralysed after forty-eight hours, dying in from three to five days. Under field conditions, however, we must expect to meet with many obstacles in the way of success, some of which, if proving insurmountable, might necessitate a modification or even abandonment of a particular line of research.

Poison Baits for Cane-Grubs.

Now that grubs are becoming plentiful we intend to investigate the possibilities ahead of this line of cane-grub control. The only previous attempt in a similar direction was made in 1916 (*see* p. 48), an account of which is given in Bull. No. 4 of our Division of Entomology. At the time this was published, arsenate of copper (Paris green) was discovered to be more deadly than white arsenic. Cowpea leaves dusted with the former arsenical were readily devoured by grubs of the greyback beetle, proving fatal to about 58 per cent. after one week, 75 per cent. after 15 days, and 100 per cent. after the lapse of 25 days. These results, which were obtained in cages at the laboratory, were thought sufficiently conclusive to warrant field tests. The matter, however, was never fully investigated, and of late years the evident claims of this arsenical were set aside in favour of white arsenic, which, although cheaper, is less effective. The recent failure of various test-plots treated with white arsenic at Greenhills and around Meringa should, I think, be attributed mainly to the methods of application adopted. In the present writer's opinion, white arsenic applied loosely in the drills in even greater quantities than 200 lb. per acre would not prove effective against cane-grubs, for the simple reason that, when chancing to ingest a portion of such treated soil, the amount swallowed would often contain only a mere fraction of arsenic; moreover, each shower of rain would tend to wash the minute particles of the poison downwards, thereby causing additional and far greater adulteration with the soil. Thus it becomes imperative, if we would secure good results, to administer the poison in as concentrated a form as possible. With this end in view we are studying the effects upon cane-grubs of various methods of placing the bait. Later on, during the planting season, the more promising of these methods will be tested by means of experiment plots in the field.

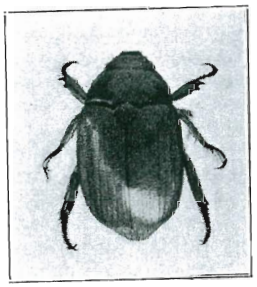
Range of Flight of the Cane-Beetle.

The topographical conditions of the country around Gordonvale probably play an important part in the distribution of this formidable cane-beetle, and, in the writer's opinion, may even be responsible for its occurrence in overwhelming numbers on certain restricted areas.

We know that, in many kinds of insects, migration of the adult or imago form often becomes necessary to the persistence of a species, and may at times lead to its excessive increase. Our cane-beetle, for example, when chancing to occur in exceptional quantities over a small area, does not, I think, remain and breed there, unless imprisoned, as it were, by mountain ranges lying to leeward of the trade-wind, knowing instinctively the many dangers that threaten crowded numbers; but generally migrates if possible, in order to distribute its eggs more widely, and so establish its grubs in a varied assortment of soils, thereby reducing the percentage of mortality caused by parasitic and predaceous foes.

Recent observations made by the present writer have been confined to an elementary study of the topography of a limited area around Gordonvale, comprising about 1,000 square miles of forest land, interspersed with patches of virgin scrub, and bordered on three sides by mountains. The south-east trade-wind sweeps across this vast level stretch of country in a direction indicated on Plate I by a large grey arrow, operating as an irresistible agent for the conveyance in a north-westerly direction of insects lacking strong powers of flight, but necessarily opposing the attempts of such to progress towards the south-east.

Many strong-winged insects enjoy a very extended range of flight; certain butterflies, grasshoppers, and moths affording familiar examples. Weak fliers, on the other hand, including the beetle under consideration, are forced to rely chiefly on the wind as a means of transport, the measure of success achieved by any species depending of course on its size, strength, and degree of buoyancy.



"CHRISTMAS BEETLE"
(*Anoplognathus boisduvali* Boisd.)
(nat. size).
Photo., W. C. Dormer.

Our greyback cockchafer, which is about 1¼ inches long and of somewhat bulky proportions (*see* p. 1), would seem at first sight quite unfitted for extended aerial transportation. While studying the anatomy of this insect, however, in 1916, I was surprised to discover that related Scarabæidæ of smaller size were decidedly heavier than this species.

It has been estimated that 1 lb. of greyback beetles represents about 216 specimens; so that, in spite of its bulk, a single indivdual weighs on an average only 2 scruples—viz., the weight of an ordinary wine-cork. The so-called "Christmas beetle" (*Anoplognathus boisduvali*), an insect scarcely half as big, proved slightly heavier; while a rutelid beetle (*Calloodes grayanus*), although not three-quarters the size of *albohirtum*, turned the scale at about 2½ scruples.

These differences in weight, which were determined from living specimens, are due to variations in the consistency of the harder portions of the body known as the outer or exo-skeleton, which in *albohirtum* are so thin as to be almost leathery in texture (parchment-like or coriaceous), but in *boisduvali* and *grayanus* are comparatively thick and horny.

As a general rule, weakly flight, coupled with large size, tends to retard the spread of moderately heavy insects, although, where such drawbacks are combined with unusual buoyancy, they are likely to aid rather than hinder rapid distribution; especially when, as in the present instance, bulk is accompanied by a proportionate expanse of wing.

In short, it appears likely that the dispersion of our cane-beetle and its occurrence locally in concentrated numbers should be attributed primarily to influences of a meteorological nature, operating in conjunction with such factors as mechanical condition of soils, character and disposition of timber, and, more especially, the geographical situation of the higher lands and mountain ranges.

March 1922.

Weather Notes.

During the past four weeks 10 inches of rain has fallen here, promoting vigorous growth of the cane. On land where grubs are present, however, excessive wet at this time of year often proves detrimental to autumn-planted cane, which, when standing in super-saturated soil of a light character, needs the support of every root to prevent it from being blown over. This applies more particularly to early planted crops of D. 1135, which are at present (25th March) carrying canes eight to ten feet in length.

With regard to late planting, it is worth recording that a 10-acre paddock of the above-mentioned variety, planted by Mr. D. McCaul at Meringa last December, the stools of which are now about four feet high, looks very promising, and is holding up well in light volcanic soil under very wet conditions. This paddock was kept bare during the flighting season, so that in all probability the beetles passed it by when ovipositing.

Naphthalene as a Fumigant for Cane-Grubs.

We were interested also to learn from Mr. McCaul that See Chin, who succeeded in cane-growing at Greenhills in the past, is said to have made use of moth-balls as a deterrent against cane-grubs.

In this connection it may be well to mention that, during November last, various experiments with naphthalene were carried out by the writer at Meringa Laboratory. Doses varying from ¼ to 1 scruple were placed in cages holding about 13 cubic inches of moist soil, each enclosing a grub of the small brown cockchafer (*Lepidiota frenchi* Blackb.).

When examined twenty-four hours later, about 65 per cent. of these grubs were on top of the soil, half of them being in a dying condition, while the remainder were found below ground and apparently normal.

At the end of two days (19th November) 35 per cent. were dead, and the remainder either sick or dying. Five days after treatment, when the soil had become more or less flavoured with an odour of naphthalene, all grubs usually succumbed after forty-eight hours. Grubs killed by this fumigant became flaccid, and before decomposing turned a peculiar pinkish-yellow colour.

Field tests did not yield satisfactory results. The odour from injections weighing ¼-oz., when buried in both heavy and light soils, did not, after a lapse of five weeks, penetrate in either farther than from 1 to 1½ inches.

Unfortunately, laboratory experiments indicate that grubs of the greyback cockchafer are less susceptible to the smell of naphthalene than those of *frenchi*. For example, a third-stage grub of the former beetle confined about 2½ inches from an injection was found after an interval of three weeks to be quite unaffected. Our outside tests, however, were made during the wet season. Under dry conditions porosity of the soil would naturally be more favourable, and doubtless the odour would penetrate farther. It may be mentioned that naphthalene does not injure cane-roots, and that the commercial flaked form is stronger than that sold under the name of "moth-balls."

Grubs at Greenhills.

This estate was visited on the 20th instant, and although the cane on some portions is destroyed, or showing unmistakable signs of grub infestation, it was interesting to find that the ravages of this pest had in some measure been controlled by the use of carbon bisulphide. Owing to the courtesy of the manager, Mr. Hoelscher, and Mr. Flower of Hambledon plantation, we were able to note results of experiments with this fumigant carried out by the C.S.R. Company last month (February) on Block J 6. A number of ¼-acre plots, treated at rates of from ¼ to ¾ oz. per stool, are already showing encouraging results. Examination of one of the stools, on a control plot which had lost most of its roots and was fast turning yellow, revealed the presence of four grubs of *albohirtum* (greyback beetle), three in the second and one in the third stage of growth; while close alongside, on a plot treated with ½-oz. per stool, the cane showed no signs of injury, was quite green, and possessed an abundance of feeding-roots.

With regard to general infestation, it may be mentioned that on Block N 2, near the western boundary of the estate, where the cane is fast turning brown, we found about a dozen grubs under each stool, fully 60 per cent. of which were still in the second stage.

Manurial Value of Cane-Beetles.

An analysis of a certain sample of beetle-meal, prepared at this laboratory last January from dried bodies of greyback beetles, has been received from our Agricultural Chemist, and on the whole may be considered as favourable. Mr. Brünnich reports: "The value as a fertilizer is about £11 per ton, and higher than that quoted for European cockchafer." A few of the details of this analysis were as follows:—Nitrogen 10·20 per cent.; phosphoric acid 1·66; potash 1·75; lime 0·27; proteins 63·75; fat 4·82.

It will be noticed from the above that this beetle-meal possesses a high food value; but, unfortunately, the sample submitted contained 0·16 per cent. of arsenic. On this account Mr. Brünnich, when referring to the food value, remarks: "The use as a food for birds or fowls is doubtful on account of the fairly high amount of arsenic contained in the sample. If the arsenic could be eliminated the beetle-meal would be a very valuable fodder."

In the present instance arsenic may have been derived from cane-land treated with this poison in hope of destroying the grubs. As much as 200 lb. per acre has been applied on some plantations, and as grubs are continually ingesting soil for sake of the organic matter it contains, and passing it through their bodies, the arsenic swallowed in this way, although not enough to prove fatal, might accumulate during the larval condition, and being absorbed into the system might be passed on through the pupa to the beetle.

A Note of Warning.

The foregoing notes, coupled with the fact that growers here are remarking at present upon the scarcity or total absence during the last eighteen months of ibises and other grub-eating birds, appears significant, and I think it would be advisable to discontinue the practice still favoured by some growers of sprinkling large quantities of arsenic in cane-drills; seeing that this has not so far proved effective against the grubs, and may result in the destruction of our useful insectivorous birds. If a large bird like an ibis, for instance, were to fill its stomach with grubs, each containing a small proportion of arsenic, it might in this manner easily obtain an accumulated dose of poison sufficient to prove fatal.

Parasite of Beetle-Borer.

Very shortly, upon commencement of the normal dry season, we intend pushing forward the distribution of tachinid-fly parasites; this work having been postponed during wet humid conditions experienced here from January to March, which are favourable to spore germination of the entomogenous fungus *Empusa* sp., a vegetable parasite of tachinid flies.

It is satisfactory to be able to report that we have now succeeded in establishing these useful parasites in the Gordonvale district. Specimens bred in our laboratory, and liberated at Riverstone last December, commenced at once to breed in the field, producing the first brood of flies five weeks later, 22nd January.

Owing to the interest taken in this work by Mr. G. Alley, the standing cane in which the flies had been let go has been left uncut, and the third brood of parasites, due to appear from this cane next month (April), will, it is hoped, spread throughout that district, and prevent the borer from doing further serious damage.

At Mount Sophia, flies were released on 6th January, and about eight weeks later, when scouting for results, Mr. W. C. Dormer, assistant to entomologist, found a specimen of the fly among the cane. This, no doubt, was a survivor from the first brood, which had emerged about three weeks earlier, but served to show that the parasites had been breeding there. Possibly other flies arising from this brood may become established in that locality.

April 1922.

Methods of Combating Cane-Grubs.

It is not generally known that we recognise at this laboratory at least fifteen methods of combating our greyback cane-beetle during its grub stage. These methods have been numerically arranged below according to their relative value as controlling factors, and may be very briefly enumerated as follows:—(1) Soil fumigants; (2) poison

baits; (3) hand collecting; (4) soil repellents; (5) cultural methods; (6) larvicidal solutions; (7) introduction of parasitic insects; (8) entomogenous fungi; (9) encouragement and breeding of insectivorous birds and mammals; (10) encouragement of indigenous parasitic and predaceous insects; (11) traps and cover-crops; (12) introduction of bacterial diseases; (13) electrical control; (14) mechanical control; (15) explosives.

It would, of course, be impossible for us to fully investigate *all* of the above-mentioned control methods, any one of the first seven of which could well engage the continuous activities of an entomologist. This fact may be more readily grasped when it is borne in mind that these fifteen controlling factors relate exclusively to the grub stage; and that we recognise also, and have been investigating so far as time permits, at least eight additional important methods of attacking *albohirtum* during its aerial condition in the beetle form.

Then again, various methods of coping with the egg and pupal stages have been studied by us to some extent; with the result that quite recently (August to November 1921) we have discovered that this cane-pest can be destroyed during both of these obscure stages of its life-cycle by fumigating the soil with carbon bisulphide.

Naturally we are hoping that experimentation now in progress may yield positive results of an encouraging nature, but, as a rule, such success is often preceded by a long series of negative results; which, however, serves a useful purpose by narrowing one's field of observation, thus tending to direct research work into more and more promising channels.

Value of Soil Fumigants.

Obviously the control methods entitled to first consideration in the list given above are those which may be supposed to hold, as it were, the key to the solution of the cane-grub problem.

In the writer's opinion the claims of No. 1, *soil fumigants*, stand first and foremost as offering the best chance of successfully dealing with the grub stage of our greyback cockchafer.

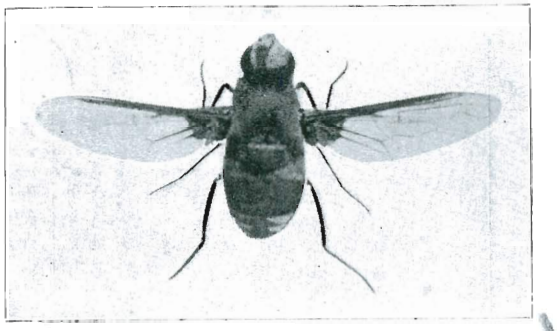
Under this heading we have such substances as sulphurous anhydride, carbon bisulphide, &c., the latter of which we have used successfully against the grub for many years past.

If bisulphide of carbon could be administered quickly and evenly by means of suitable machinery it would, I think, be a decided step in the right direction, and relieve the present situation very materially. At the same time we do not, for several reasons, consider that nothing better can be found. During the past two months many fumigants have been tested by us with varying degrees of success. Time and again, as might be expected, the hopes raised by apparently conclusive laboratory experiments have been dispelled after testing same in the field. Nevertheless, our results taken collectively have been sufficiently encouraging to warrant closer investigation along similar lines.

Introduction of Parasites.

When reporting on this interesting question in July (1921) I mentioned that various entomologists had been consulted with a view to obtaining reliable and comprehensive data regarding certain scoliid parasites likely to be serviceable if introduced into Queensland.

During the interval that has elapsed since that date, replies to my list of questions have come to hand from Dr. Guy A. K. Marshall, of the British Museum, and Prof. F. Leffmans, Government Entomologist, Buitenzorg. The former entomologist mentions six species of Scoliidæ that might meet our requirements. One of these, which resembles our own digger-wasp in colour but is slightly smaller, inhabits New Caledonia; while three are from Dutch New Guinea, one from Solomons, and one from Aru Island. He is of opinion that a number of other species hitherto uncollected are likely to occur in the more accessible portions of British New Guinea.



HYPERPARASITIC "BEE-FLY"
(*Hyperalonia satyrus* Fabr.)
(about 1½ times nat. size).

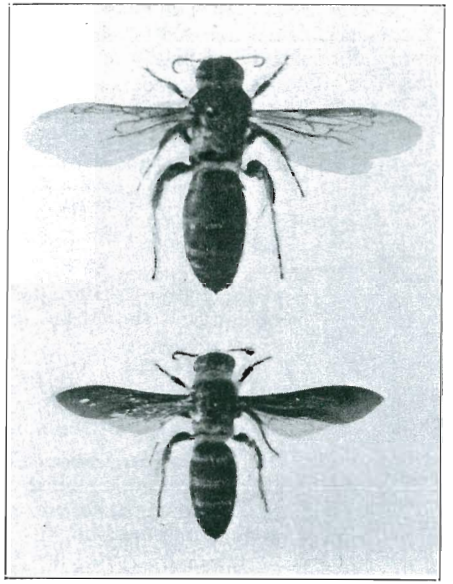
Photo., W. C. Dormer.

It was very interesting to learn that the principal insect enemy of our scoliid wasps has not, up to the present, been received by the British Museum from New Guinea; so that, very probably, wasps introduced from there may be immune from attacks of the hyperparasite (*Hyperalonia satyrus* Fabr.) which helps to control the increase of our own digger-wasps.

Professor Leffmans has kindly enumerated nine species of Scoliidæ that are parasitic on scarabæid grubs in Java. Three of these appear very promising, and might if introduced here attack our cane-grubs; one of them, in fact (*Dielis thoracica* Fabr.), being about the same size as our own principal digger-wasp, and parasitic upon grubs of *Lepidiota stigma* F., a cockchafer belonging to the same genus as our cane-beetle *Lepidiota frenchi* Blackb. *Dielis thoracica* also destroys the grubs of *Leucopholis rorida* Fab., a cane-beetle similar in size to our greyback beetle.

Dielis thoracica, which is the most promising and abundant digger-wasp, occurs in East Java, and on the south coast of Sumatra, where it is found practically throughout the wet season, and also during the dry monsoon of six months. In general it is confined to areas badly grub-infested, attacking second and third stage grubs of four different scarabæid beetles. Its life-cycle occupies from thirty-nine to sixty-two days, the intra-cocoon stage being longer than that of our digger-wasp

Campsomeris tasmaniensis Sauss., which has a life-cycle of from forty-three to forty-eight days. Forty-two eggs have been obtained by dissection from one female *thoracica*, although in all probability this species, like that of our own digger-wasp, is able to produce about twice that number.

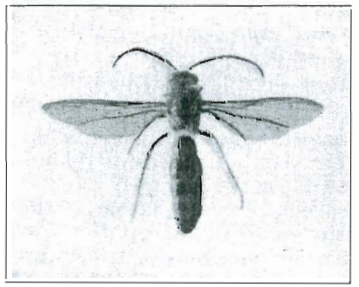


1. *Campsomeris tasmaniensis* Sauss., female.
2. *Campsomeris radula* Fabr., female.

(Slightly enlarged.)

Photo., W. C. Dormer.

In Java the adult wasps of *thoracica* frequent honey-bearing flowers belonging to the orders Compositæ, Malvacidæ, &c., including those of genus *Sida*, three species of which occur commonly around Meringa, and are habitually visited by our *Campsomeris* wasps.



DIGGER-WASP PARASITE
(*Campsomeris tasmaniensis* Sauss.), male.

A bombylid and some conopid flies are suspected of being hyper-parasites of *thoracica* and other scoliids in Java; but Professor Leffmans does not consider these of much economic importance.

On the whole the situation with regard to *Dielis thoracica* appears hopeful, and, in the event of its hyper-parasites not occurring in Queensland, conditions here should be very favourable to the increase of this useful insect. This matter of secondary parasites, however, will be further studied.

At all events, we purpose as a preliminary step to obtain with as little delay as possible living specimens of *thoracica*, and of *Dielis javana* Lep. (another species likely to prove useful here), for purposes of breeding and study at this laboratory.

Owing to the length of the intra-cocoon stage of both these wasps, Professor Leffmans believes that cocoons containing living pupæ could be successfully shipped to Australia. We hope, therefore, to be able to arrange for an exchange of parasites, and have already advised him of our willingness to forward to Java cocoons of *Campsomeris tasmaniensis* in return for those of *thoracica* and *javana*.

A New Moth-Pest of Cane.

We have to record another addition to our lepidopterous pests of sugar-cane, viz., *Spodoptera mauritia* Boisd. Hampson, one of the so-called grass or army worms, which affect cane in Hawaii; where, before the introduction of the mynah bird, it was reported that whole fields of cane were often completely destroyed by this noctuid.

The eggs of this moth are laid in batches of an oblong or circular outline, consisting of 60 or more eggs deposited side by side and covered with a pinkish-brown felted mass of hairs taken from the body of the insect. Each female probably deposits in all from 350 to 400 eggs, affixing these batches to leaves of bushes, ceilings, walls, &c., &c., but usually in situations immediately over or close to herbage; and the tiny larvæ upon hatching drop down on threads of silk until reaching grass-blades. About eighteen days later, when fully grown, they measure 1¼ inches in length, and are then greenish brown, with yellowish sub-dorsal and spiracular bands, the former having a dark line on the lower edge, while the latter is placed just below spiracles. The anterior dorsal portion of each body segment excepting the first encloses two triangular black patches, which are very variable, and in some specimens appear as short thick streaks. Spiracles dark-brown. Ventral surface greenish yellow. Head greenish brown with face yellow, and mandibles dark red. Body cylindrical, tapering slightly towards each end, and bearing a few scattered black hairs.

Pupation takes place underground, this stage occupying a period of three weeks.

Caterpillars of this grass-worm were observed by the writer defoliating cane growing in cages used for breeding tachinid-fly parasites.

Fortunately this new moth-pest is of very minor importance at present, and not likely to prove troublesome in the future.

This is the eighteenth lepidopterous insect observed injuring sugar-cane in Queensland.

May 1922.

Condition of Cane Crops.

About the middle of last month (15th to 26th April) a nice fall of rain (6·13 inches) relieved a situation which to many cane-farmers was becoming increasingly serious. In my report for November last it was mentioned that beetles had appeared here in alarming numbers during the 1920 to 1921 season, but that fortunately prolonged wet

conditions had enabled the cane to reach a good length before grubs were large enough to do much damage. Although present in considerable force at that time, showers and cloudy days during the critical grub period had kept the tops green, while sticks that had fallen were able to root afresh and so keep alive until crushing time.

As foretold in the above-mentioned report, beetles were very much in evidence again this year (1921-22), and, being unchecked by any collecting, have succeeded in spreading farther afield, and injuring cane in various localities which up to the present have been comparatively free from the pest.

On some blocks at Greenhills the cane was completely destroyed, in spite of a favourable wet season, and this at a time when grubs were still in their second instar (half grown); showing the severity of the present infestation. Had dry conditions continued during the past six weeks, many growers would have lost heavily. It is to be hoped, however, that the recent rainfall, and an additional precipitation of 1·23 inches (30th April to 4th May) may tide us over the worst period of grub activity.

Collecting at Greenhills in the Past.

Desiring to learn something of the methods of cultivation and grub control practised at Greenhills in the early days of cane-growing, we have got into touch with Mr. See Chin, who tells me that while at Greenhills he planted about one foot deep, and on the whole obtained good crops.

It seems that he tried "moth-balls" when planting as a grub deterrent, but without success; so that his field experiments with this form of naphthalene gave similar results to those obtained recently at our laboratory (*see* March report, 1922).

Beetles were systematically collected and destroyed by him, this being apparently the only artificial control method that yielded beneficial results.

Mr. See Chin is of opinion that when early thunderstorms are followed by about a week of continuous rain there will be plenty of grubs the following year; but that if one or two wet days be succeeded by dry weather lasting from four to six weeks there will be fewer grubs.

This information regarding the influence of climatic conditions as a controlling factor during the period of oviposition may prove to be of decided economic value, as it is only by such observations, extending over many years, that we can hope to acquire definite knowledge respecting various phases of natural control, and so be in a position at the end of the flighting season to form an approximate estimate of the probable strength of the enemy.

Cane H. 146 at Riverstone.

A sample of this variety, which is credited with being practically immune from attack by the weevil-borer (*Rhabdocnemis obscura* Boisd.), was obtained last year from South Johnstone Experiment Station, and a row about three chains long planted on 24th September at Riverstone, near Gordonvale, on land where the borer had proved troublesome the previous season. The sets had lost a good many buds during transit, so unfortunately there were many misses.

When examined on 25th instant (eight months later) the result of this experiment was seen to be very encouraging, the canes in stools of H. 146 being much longer, stouter, and of more vigorous appearance than those in adjoining rows of D. 1135.

Apparently this new cane is going to suit the district, and, although resembling the latter variety in general habit of growth, possesses the following additional advantages:—The c.c.s. is 15·54, or 1·04 higher than D. 1135, and the canes are stouter and longer.

This promising variety, which was introduced into Queensland from Hawaii by the Bureau of Sugar Experiment Stations a few years ago, is a medium stout, olive-green cane, with slight black wax, eyes large and flat, internodes to 5 inches, zigzag appearance, habit erect, foliage thin and sparse, resembles D. 1135 in growth, good striker and ratooner, rapid grower, practically self-trasher. Age 11 months; fibre 11·5; density of juice Brix. 21·2. (D. 1135=age 11 months; Brix. 19·03; fibre 11·00.)

Its grub-resisting qualities have not been determined, but in all probability it should be equally if not more resistant than D. 1135.

Experiment Plots at Meringa.

The plots at Carrah, which had been treated between the dates 12th November and 8th December, were inspected early this month (May).

The various insecticidal substances applied to the surface of the soil, with a view to inducing beetles to avoid ovipositing in the treated areas, were naphthalene, chloride of lime, coal-tar, tobacco dust, and carbolineum emulsion, the size of each plot being one-eighth of an acre.

The methods of application, and the enduring qualities of the odours arising from these deterrents, were reported last December (p. 70).

At the present time (6th May), the cane on both the treated and check plots looks to be about the same height and general appearance, but grubs have not yet done sufficient damage to enable one to form an opinion as to probable results of the experiments. In about a month, after grubs have ceased feeding, it may be possible to arrive at a definite conclusion.

Trap-Trees for Cane-Beetles.

In 1896 the "Australian Sugar Journal" made mention of a certain tree growing at Mackay that for two years in succession had been crowded with cane-beetles, which, after feeding on the foliage, fell to the ground in a sort of paralysed condition and then died.

Being anxious to test the effect of this tree on our cane-beetles here, the owner, Mr. James Croker, very kindly forwarded me a number of suckers taken from the identical tree (a species of persimmon alluded to in the above-mentioned journal); while later on (4th May) he was interested enough to follow up this with three fruits from the same tree, so that seeds have now been obtained and planted here.

Two of the suckers are growing, but have not yet made much headway. Probably the seedlings may make more rapid growth.

In any case, by the time the next lot of beetles emerge there should be enough leaves on the suckers to enable us to test the value of this plant as a possible trap-tree in our district.

Tachinid-Fly Parasites.

Breeding operations are now under way at the laboratory, and the first lot of flies, from which we intend getting up our stock for liberation by rearing successive broods, have been obtained from the Riverstone district, where twenty-five specimens were let go last December among bored Badila cane belonging to Mr. G. Alley. This cane, by the way, which was considered too badly infested to be worth cutting, has now been cleaned up by the parasites, the result being a fine healthy-looking crop harbouring very few cane-borers. Pupæ of the tachinids were obtained from cane-sticks in the field twenty-four days after liberation, and flies belonging to the first brood emerged exactly five weeks after first introduction of the parasites.

Judging by these results December appears to be a good month to liberate tachinid flies, since at this time of year specimens of the first brood emerging early the following month (January) have time to enter upon the second brood before commencement of the wet season, when the *Empusa* fungus parasite of this fly usually appears on the scene.

Flies resulting from this second brood about the middle of February, having by that time run into four figures, should then have a good chance of becoming permanently established.

Growers visiting Meringa Laboratory during the next few months will be able to see tachinid-fly parasites breeding in confinement, and also observe the life-cycle stages of our digger-wasps, from the egg (laid on the paralysed host) to the maggot, cocoon, and finally the imago or perfect insect.

June 1922.

Grub Fumigation at Greenhills.

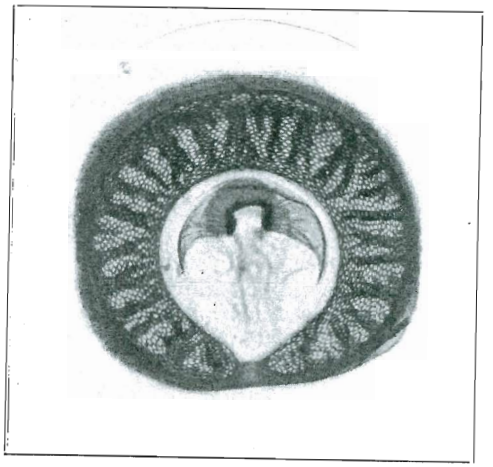
Experiments with carbon bisulphide, carried out by the Colonial Sugar Refining Company against cane-grubs at Greenhills last February, have yielded data that should prove serviceable when dealing with the beetle pest next season.

The cane on block J 6, which was fumigated towards the end of February, after evidence of grub attack, appeared at first likely to recover (*see* March report, page 80), but did not ultimately regain sufficient hold of the ground to withstand subsequent dry conditions experienced from 17th March to 15th April; which being accompanied by strong winds during the latter month caused the cane both in treated and control plots to fall over. This experiment shows the advisability of fumigating early in the season at a time when grubs are not large enough to materially injure the main roots, while the soil also is usually in drier and better condition for such treatment than is the case later on during the wet season.

A capital instance of benefit to be derived from early treatment may be seen at Greenhills just now (20th June) on block J 6, where the manager, Mr. Hoelscher, fumigated a ¼-acre plot before the cane exhibited external indications of grub affection.

This plot of Badila received ½-oz. of carbon bisulphide per stool, ¼-oz. doses being given on each side; while the adjoining block was not fumigated. Although the cultivation, manuring, and character of the soil was similar on both plots, the cane on the check will be seen to be noticeably shorter than that growing on the treated area, this being due to the presence of grubs, which by repeatedly severing the surface feeding-roots close to the stools have caused the plants to become stunted.

As previously reported last April (p. 82), it is possible to successfully fumigate not only the grubs, but both pupæ and eggs of our grey-back cockchafer. The chorion or egg-shell, a fragment of which is shown highly magnified on page 40, is coriaceous or leathery in texture, and being slightly porous offers but feeble resistance to the entrance of bisulphide fumes. A newly hatched grub, however, breathes by means of spiracles, of which there are nine on each side of its body, opening directly into trachæ that subdivide again into smaller and still smaller air-tubes (*see* illustration). During this life-cycle stage it is of course very susceptible to fumigation, even while in its first instar and too small to seriously damage cane-roots. Then again, the spiracles of the pupa, which are even larger than those of the grub, afford ready admittance to gaseous fumes (*see* illustration on p. 57).



Spiracle of Grub of *Lepidiota frenchi* Blackb. (× 70 times).

Photo., W. C. Dormer.

In normal seasons bisulphide fumigation should be commenced about the middle of January, as soon as all grubs have hatched and are mostly in the first stage (about half-an-inch long); the ground at that time of year being usually in good condition for such treatment. Later on, after the rainy season has set in, excessive moisture interferes with soil porosity, and moreover, grubs being then in the third stage have started to seriously injure the root system.

D. 1135 at Highleigh.

Learning from Mr. Wilson Irvine that D. 1135 was doing well in the above-mentioned locality, and, as a result of careful cultivation, had shown a marked tendency to produce abnormally stout canes, a visit was made to Highleigh on the 15th instant, when Mr. J. Cannon drew my attention to certain stools of this variety planted by him during August and September (ten months back) which were bearing exceptionally fine canes.

The block planted in August was manured with "Howe's Mixture," but no lime had been applied; while the September planting was treated with 35 cwt. of lime per acre.

Seeing that D. 1135 appears to thrive well in the Cairns district, and is more resistant than Badila to attack from root-eating Scarabæidæ, and also to the weevil-borer (*Rhabdocnemis obscurus* Boisd.), our growers should not fail to embrace any chance of obtaining an improved strain of this variety. This can be done very simply by selecting only the stoutest canes for seed purposes. These should be planted together on a small area, all sets being cleanly cut in order to minimise risk of invasion from fungi, and at the same time examined for red-rot or weevil-borer, &c. If taking the trouble to plant a patch in this way, most of the resultant stools would be found to consist of stout canes, some tending to be finer than any of the selected seed. By again using, for seed, cane derived from a plot of this kind, a few acres of an improved strain of uniform quality throughout the plantation could be obtained in the shortest possible time.

Such artificial selection is within the reach of every intelligent farmer; and since Nature's law that "like produces like" is indisputable, any time or attention so expended could not fail to yield a substantial return from a monetary standpoint.

It should, however, be borne in mind that when growing a patch for seed in this manner land chosen for the purpose should if possible be of uniform character, and receive similar treatment as regards manuring, subsequent cultivation, &c.

Cairns Show Exhibit.

Some time was spent this month in the preparation of entomological specimens, &c., for exhibition at the annual meeting of the Cairns Agricultural, Pastoral, and Mining Association.

Our exhibit took the form of coloured diagrams and charts, illustrating for the most part the underground workings and life-cycle stages of our principal cane-beetle, and effects produced by this pest upon the growing crop during each month of the year. A small general collection of insects, of the eggs, grubs, and pupæ of root-eating Scarabæidæ affecting cane, and other exhibits of a scientific nature dealing with the chief parasitic and predaceous enemies of our cane-beetles and their larvæ, were also placed on view.

This exhibition was well attended, and many growers availed themselves of our invitation to freely discuss the questions of grub and beetle control, with the result that much interesting exchange of opinion took place regarding several complex phases of the all-absorbing cane-grub problem.

Early History and Origin of the Grub Pest.

Damage to cane from attacks of cockchafers is recorded as having occurred first at Mackay, as far back as 1872; and twenty-three years later (1895), when this trouble had assumed a serious aspect, Mr. Tryon was asked to investigate the matter and recommend measures for controlling the pest. About that time grubs were beginning to make their presence felt around Cairns, and we find Mr. S. W. Davids—then manager of Mulgrave Central Mill—in his annual report for 1897, calling attention to the appearance of grubs and cane-beetles in various spots in the neighbourhood of Gordonvale, and suggesting that steps be at once taken to check the evil. His advice was acted upon, but, as is usual in such cases, the matter was not regarded seriously by the growers.

The following year Mr. Davids reported as follows:—"The ravages of the grubs are very evident, and unless steps are taken at every opportunity to destroy the grubs and beetles when met with we may look for the same disastrous results as experienced in other sugar districts."

The above correspondence is doubly interesting from the fact that, in addition to throwing considerable light on what may be termed the prelude to an invasion that a few years later assumed colossal proportions, it also helps us to determine the source from which most of the present trouble originated.

Data obtained by the present writer in 1915 goes to show that infestation of the cane-lands around Gordonvale was in the first instance brought about by beetles that did not originate in that locality, but were transported there from extensive breeding grounds situated either in the vicinity of Aloomba or several miles westward of that district.

This view of the case is not merely theoretical, but may be taken as being an established fact, verified by the experience of leading growers, many of whom have had unique opportunities of observing the gradual encroachment of this pest during the past twenty to twenty-five years.

Mr. R. E. Riley, sometime cane inspector at Mulgrave, who during his long residence at Gordonvale made many interesting observations in this connection, appears to have been the first to notice in the early days (1897) that our greyback cockchafer bred habitually in countless numbers around Aloomba over extensive areas covered by the so-called "blady grass" (*Imperata arundinacea*), which is one of the commonest native food-plants of the grubs of this beetle. Subsequent observations by the writer have shown also that its grubs subsist very freely on roots of other Gramineæ, notably those of the carpet grass (*Paspalum platycaule*), that often covers recently cleared scrub lands.

Space forbids further enlargement of this question, but the foregoing evidence throws additional light, I think, on the much-vexed question of collecting beetles and grubs of this pest.

When cane was first planted at Gordonvale no serious injury followed until some years later, from which we may infer that, if beetles are systematically collected in any given locality, others do not, as some growers imagine, immediately take their place, but reinfestation from the outside bush is a matter of time, perhaps of some years.

Any beetles chancing to invade such cleaned-up localities the following season may, therefore, be presumed to come from adjoining cultivated areas that had not been collected over; so that benefit would result as a matter of course, although not always to the deserving parties. If, however, a general systematic collection could be made throughout our district and kept up for a few years, destruction of the vast host which have gradually entrenched themselves, and are now breeding within the tract of country devoted to the cultivation of sugar-cane, could hardly fail to afford a measure of relief.

The foregoing evidence seems to me to be supported by past experience at Mackay, and, I believe, in other sugar-growing centres; where it has been noticed that when collecting has been discontinued, owing to a scarcity of beetles, a few years have generally elapsed before a fresh invasion of the pest has again called for action.

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