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The White Grubs of Sugar Cane in Queensland

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

Sir,—I have the honour to recommend for publication Bulletin No. 1 of the Division of Entomology of the Bureau of Sugar Experiment Stations by Mr. A. A. Girault.

Some time prior to the termination of Mr. Girault's engagement it was arranged that he should prepare a bulletin comprising the work carried out by himself and his assistant, Mr. A. P. Dodd, on the cane grubs of Australia. Necessarily this would require to be a scientific publication containing descriptions and measurements for the benefit of the science of entomology in general and the terminology would be largely technical.

It was recognised, however, that canegrowers would not be able to gather much information from such a bulletin, and accordingly Mr. Girault was requested to prepare the following paper, embracing his work during the past three years and his views upon the subject in as plain and concise a manner as possible.

I have, &c.,

HARRY T. EASTERBY, General Superintendent.

The White Grubs of Sugar Cane in Queensland.

By A. A. GIRAULT.

White grub is the popular name given to the young of certain members of that great family of beetles called by the entomologist the Scarabæidæ, and popularly known in America as May or June beetles, in Europe as Cockchafers, and in North Queensland as Cane beetles, Christmas beetles, and so on. These beetles and their young are familiar to the average canefarmer, and for our purposes it is not necessary that they should be tiresomely described to him since such descriptions are meant for the entomologist, and serve their purpose when they have served him. The farmer, to whom this writing is addressed, wants to know, first of all, what he is to do when directly faced with an attack of these insects, and thereafter he is more or less concerned about what is known of them. Unfortunately, we can write much more on the latter phase of the subject of Cane beetles than upon the former; but it will not do to belittle this knowledge at all. We must know much more than at present. Though directly the farmer, like the Doctor's patient, is little concerned with the body of knowledge underlying practice, yet ultimately it concerns him, still like the patient, very much. If the Doctor is ignorant, or the combination of bodies of knowledge making up the complicated science of medicine is deficient, the patient gets the worst of it; if the entomologist is dull and stupid, or the science of entomology backward, the farmer gets the worst of it. The farmer then, in a restricted sense, is the patient of the entomologist. He should therefore be much concerned in the body of knowledge which the entomologist has at his disposal, and it is the purpose of this Bulletin to show as plainly as possible what progress has been made so far in additions to the body of knowledge on white grubs.

For the past three years the Queensland Government has been investigating white grubs, and this investigation is the first ever seriously undertaken on a separate problem. In North America, the problem has never been given undivided attention, nor in Europe. Where studied at all, insurmountable difficulties were nearly always encountered, for these insects, living as they do hidden in the soil for most of their life, are difficult to study. So that this investigation is practically a pioneer one. On this account the purely entomological side of it had to be undertaken first, because the entomologist must know all that is possible before

he can go to work intelligently, and not waste his time and energy in working in the dark. The practical side of the problem thus has been largely ignored. First of all, it was necessary to rear the grubs to maturity so as to identify them, and then study separately the rather large number of species found to be actually involved in the problem. Are the habits of these alike? Are they all to be included in the problem? Are they habitual canefeeders? Are they restricted to certain kinds of soils? Are they partial to certain kinds of vegetation? These and a number of other questions have had to be answered by the gradual accumulation of data, and it is upon this data, published elsewhere, that the following account of our present knowledge of the Queensland Cane grubs is based.

INSECTS AND BEETLES.

As we are concerned with certain kinds of insects, it may be worth stating that an insect is an animal of small size characterised by bearing, when adult, three pairs of legs, and in having both sides of its body alike or paired, usually winged and always divided into three body regions—namely, head, thorax, and abdomen. The body has an external skeleton and no bones, and breathing is accomplished by means of a series of pores along the sides of the thorax and abdomen. Reproduction or birth is usually accomplished by laying eggs, and the young after hatching may or may not resemble the parents. They grow by a series of moultings or casting of the skin, some insects growing directly into the adult, others entering a resting or chrysalid stage, being then developed into the adult.

Beetles are insects of the latter kind, they are characterised by having the upper pair of wings hardened like the external body skeleton, and by their way of growing and the form of their young. Briefly, the adult lays eggs, and these latter hatch into a six-legged grub, which eats and grows, moults a number of times, and then changes into a chrysalis or pupa, which develops into the adult. Both the adult and the grub possess powerfully biting mouths; the former is quite active while the latter is usually sluggish. Beetles lay eggs.

Insects are the most numerous and successful of all animals, and there are still many kinds unknown. About seven hundred thousand species have been described. About a thousand species live upon the apple of commerce throughout the various regions in which this fruit is grown. Their habits and development are most diverse.

The Origin of Cane Beetles in Queensland.

If we should make a short journey into the open forest country in any part of Australia, or into the jungle, and should spend a little time in poking about into the soil under logs and elsewhere, there would doubtless be met with several examples of beetle grubs, which, upon examination, would be found identical with those attacking cultivated crops; if in the coastal areas of Queensland, they would be identical with some of those found now in the canefields. Thus, these insects are natives, and occur in enormous numbers through all of the uncultivated

land surrounding the farm. They occur in enormous numbers wherever organic matter of vegetable origin is, whether this be living or dead. They even occur in the sand of dry river beds, but only in places where the darkness of the sand indicates organic matter. In the case of this sand they may be mined for such as coal is, by following the vein or layer of organic matter.

A journey into a region of virgin forest or jungle remote from cultivated cane, say about New Year's Day, would convince us that these insects are natives. The beetles would then be met with in their natural surroundings, and they would be identical with those beetles now being paid for in quantity by the various sugar-mills.

It has happened that these native insects find cultivated areas of cane as suitable for the sustenance of life as uncultivated areas of natural forest with their heavy clothing of green, and it is quite by accident that they occur amongst cane crops. That they have more or less concentrated on such areas is quite obvious from the data which has been collected.

Life History of a Cane Beetle.

Ignoring time, after the female beetle deposits its egg in the soil, the latter hatches into a small grub, which immediately commences to feed upon the first suitable material within its reach, and continuing this grows month by month into a large grub, which upon the approach of spring makes itself a cavity in the soil, or covers itself with an earthen cocoon, and therein slowly changes and finally casts its skin, disclosing the resting stage or pupa. This in turn slowly changes internally and finally casts *its* skin, disclosing the adult.

The latter requires several days of rest in order to acquire perfectness, whereupon it takes the first opportunity of making its way to the surface, where it seeks food and reproduces, thus continuing the ceaseless circle of development. The time occupied by this cycle varies with the species or kind of beetle, but is always at least one calendar year, from November to February to November to February.

The Distribution of Species.

Of the enormous number of kinds of insects on the surface of the earth, it has been found that they are unequally distributed as regards space. For example, the vast majority of Australian insects are quite different from native European or South American insects, though a large number of the groups of species are identical. So with more restricted areas. Many Queensland insects are different from those in New South Wales, and most from those of West Australia.

As a consequence of this fact, white grubs of West Australia are different from white grubs in Queensland. But, as regards those which occur in cultivated cane, they are practically the same throughout, since the sugar cane area is a comparatively restricted one, and more or less identical as to the physical features, and so on. If sugar-cane were to be

grown in North-West Australia, we should find the white grubs there more or less different from those now found in the Australian canefields. The range in latitude of the cane area, however, is sufficient to include a gradual change in species from South to North.

The Species or Kinds of Cane Beetles.

I have written right along of cane beetles, implicating that there were more than one kind. This is quite true. This matters considerably from the practical standpoint, but even were this untrue it would have been impossible to ignore the fact from the entomological standpoint. It has been found that there are about thirty species of these insects occurring habitually or spasmodically in canefields. Of these, four or five are exceedingly common. Of the total number, only a few have been properly identified, because we have as yet not succeeded in rearing them, but the general statement may be made that those species doing the largest amount of injury to the cane plant comprise a group of near relatives, included in which is the rather large greyish beetle commonly referred to as *the* Cane beetle, and upon which, at least in the North, most efforts at reduction have been directed. A few of the species never attack living vegetation.

From the standpoint of clearness, it became necessary to distinguish between the grubs or young of these various species so that those most directly concerned with our problem could be recognised. They can be distinguished by noticing their general appearance, but with certainty in many cases only by examining a certain peculiar arrangement of the hairy clothing of the body, which at certain places is characteristically arranged, this arrangement forming the scientific basis for identification. A diagnostic table for the canefield grubs has been published elsewhere.

Occurring over the vast area of the Australian continent and the adjacent islands are many more species of potential cane grubs, but most likely they will never concern the grower of sugar cane, and need cause him no alarm.

Gross Habits of Cane Beetles in General.

The life of insects is divided into a growing time and a reproducing time. The growing time commences with the egg, and ceases with the pupa or resting stage. Adult insects never grow, but their "purpose" is to produce progeny. Now growing and reproducing require sustenance, so that generally we find that most insects take nourishment at both these times, but always when growing, so that Cane beetles as a rule feed most vigorously when grubs, and less so when adults. The grubs feed continuously and gluttonously. The adults only for short intervals.

The life of many insects is also divided into a crawling time and a flying time. The grub stage is the crawling time of the Cane beetle life; the beetle can fly, and is thus literally above the rest of its existence, which is passed entirely within the surface of the earth.

Thus grubs crawl and feed upon the organic matter in the soil, as well as upon the roots of living plants. Beetles, on the contrary, both crawl and fly and feed upon the foliage of trees.

Gross Occurrence of Cane Grubs as Regards Soil.

We have been gathering facts on this for some time, and these facts show that the character of the soil, whether volcanic or loam, has very little to do with the occurrence of the various species of Cane grubs, except in the case of sand, or in places where the soil has been heavily infiltrated with organic matter of vegetable origin. As certain of the species feed habitually upon the last-mentioned matter, they occur most abundantly where deposits of this are numerous. But, as concerns those species which really attack cane, the facts show that they are about as numerous, say, in canefields of the red volcanic soils as in those of clay or clay loams. In respect to this point more data should be gathered to supplement that already obtained.

Gross Occurrence of Grubs as Regards Site.

The sites in question are upland and lowland. Our data needs supplementing, but so far we cannot conclude that there is any noticeable tendency for grubs to be more numerous in the cane on either site. By upland we mean that which is perceptibly above the common level of the surrounding farms—the crest of the waves in rolling lands, "rises," cultivated hills, and so on. Since uplands are most likely drier than lowlands, we may say also that relatively wet and dry sites are about equally infested by grubs. We exclude, of course, bogs and very wet sites, which are unsuitable for grubs on account of the fact that the sticky soil is likely to clog their breathing pores, and locomotion is difficult.

Gross Feeding Habits of Grubs.

A question of considerable importance is involved here. Dissections of every species of grub obtained by us invariably showed the presence of vegetable matter in the food canal. Now, there can be no question but that this is the best of evidence that grubs feed upon vegetable matter. Yet it throws no light upon how or where this matter has been obtained.

The occurrence in the canal also of relatively large quantities of soil tinges the question with conjectural possibilities. Thus this soil is stated to have been taken in accidentally when the grub bites off and swallows living roots—a reasonable conjecture no doubt. But the large quantity of soil matter frequently found in the canal, taken in conjunction with the fact that the statement that it is obtained in this manner is pure conjecture, and that the habit would be one of poor economy on the grub's part taking in indigestible and useless matter indiscriminately makes it evident that another side of the question turns up.

If we take a healthy grub just brought in from the field and place it into a box containing nothing but natural soil and keep the box for several weeks, we would find rather unexpectedly that the grub was still

alive and plump, not dead and shrivelled from starvation. Dissection would still show the same matter in the food canal. If we had observed the insect at all closely it would have been noticed that excrementitious matter was being passed. Nothing would be seen in fact to show that the temporary welfare of it had been at all disturbed.

Again, if we take a grub which has just hatched and notice its colour, it will be seen that it is all white about the hind part of the body. But if this particular grub is placed into natural soil without any living plant in it, and left for several days, then examined, it would have the hind part of its body dark from the food which it had taken. This food is the organic matter of vegetable origin present in the soil, and the grub obtains it by swallowing large quantities of soil and passing it through its body. That this is done repeatedly may be observed by anyone who will take the trouble to confine several grubs in a small box of soil, which after a month or two will be largely converted into the hard pellet-like masses of excrement.

From these facts, and on account of our knowledge that certain kinds of these grubs are infested by intermediate stages of certain mammal parasites which have passed from them in excrement; that starving grubs are never found in nature though grubs are quite often found in barren places or bare spots (such as along the rows in well-cultivated fields of corn) at least temporarily out of the reach of living vegetation; that many soils when moistened and examined with a lens have much similarity to the contents of food canals; that certain kinds of grubs, being habitually in veins of organic matter in nearly pure sand, have the contents of their food canals very similar to that of the general run of species including those which are known to feed upon living plants; that grubs in soil mixed with paris green die very quickly; that when confined in empty vessels they soon show signs of reverse and are much shrivelled after the lapse of a week; and that grubs, as a rule, are not habitual plant attendants, we conclude that the grubs, as a general rule, feed upon and exist largely upon the organic matter in soils. They are habitual soil swallowers. Nevertheless, with some of the species living vegetable matter appears to be a necessity for continued health and development, especially when young. Separate lots of young grubs of these species when reared side by side in natural soil and in soil with growing plants prosper in the latter and suffer in the former. The soils used in these experiments were not especially rich in organic matter, and this may account for the suffering of the lots kept in the soil of itself.

The evidence points strongly in the direction indicated. White grubs as a rule are habitual soil swallowers, but some species require living vegetation in order to survive.

The Length of the Life Cycle.

We have attempted, it must be confessed with poor success, to obtain direct evidence of this by rearing the insects from eggs in cages kept out of doors. However, partial success by this method was obtained, while

other data obtained by making systematic collections of grubs from the field have enabled us to make a definite statement in regard to one of the principal species at any rate. This is the large grey back beetle, *the* Cane beetle of the Mulgrave district and of the North in general. The cycle of this species is one year—from November to February to November to February. The three larval stages are completed several months after hatching, and our collections show that they occur during definite times of the year only. Thus, stage 1 is found from December to April. 2 from January to May, 3 from February to October. Thus, stage 1 is never found in June or later, 2 never in July or later. The large stage 3 is never found in December. These facts allow of no other interpretation than that given.

With some of the other species it is quite different, the stages being distributed over every month of the year, and this fact allows of but one interpretation—namely, that at least two years pass during a single cycle from egg to adult. These facts in regard to these species will become clearer and clearer as the data now collecting accumulates. Some of the rarer species are still unknown to us, and must be reared to maturity.

The Feeding Habits of the Adults.

The adults of the species most concerning us feed upon the foliage of various native trees, showing preference to a few. The species mostly concerned—namely, the grey-backed one—is positively omnivorous in that it attacks nearly every common bush tree and many of those of the jungle. It shows preference to certain species of figs and eucalyptus, the weeping fig, the ti-tree, the bloodwood, and the Moreton Bay ash especially. The foliage is eaten in a serrate manner from the edges of each leaf, the jaws working slowly. Feeding commences soon after emergence from the ground, preceding mating and the maturition of the ovaries. It is not extensive for each individual, but trees may be badly defoliated by their combind attacks. Food is necessary before eggs can be developed in the ovaries.

Summary of What is Known as the Cane Beetles.

The brief and very general account given of white grubs does not perhaps explain one of the main purposes of this preliminary investigation, which has been to serve the entomologist and for his purposes even is by no means complete. The fundamental thing was to find out what these grubs were, describe them and their life histories, and leave means for their identification. This is not an easy thing to do, as entomologists know, and we have had but partial success. At first rearing was depended upon to give us evidence of the length of the entire period of development, but we have not as yet succeeded in rearing a single specimen through its stages, but may succeed in doing so by the time the next beetle season arrives. At first, too, we were unable to identify the different grubs, and many of our rearing cages yielded no adults. So that at this time we do not know what many of the species are, and can

refer to them only by the numbers attached to the preserved specimens of their grubs. By a systematic collection of grubs from the field, the life cycle of the commonest species has been definitely ascertained to be one year, but the data is not as yet full enough to decide in regard to some of the less common species, and in those cases where they show the cycle to be more than one year other means will have to be adopted, *e.g.*, rearing again.

We know, then, that there are a number of different grubs in the soil, and that these can be distinguished from each other and thus studied quantitatively. In this manner the relations of each to cane itself, to the varieties of soils in cane fields, varieties of sites in canefields, and the relative numbers each to each can be obtained. We know also that other species will occur as the locality varies for any great distance. It is also known which species are concerned in injuring cane, and this in a manner simplifies the problem by elimination. The general life histories and habits, too, are known as regards the commonest species, but the intimate habits of the adult still need close observation, and may yield important results.

In economic entomology it should always be the practice to know the conditions first, and to apply this knowledge later. The conditions are not all known yet.

RECOMMENDATIONS.

From a purely disinterested standpoint I would urge those concerned to carry on the investigation. Even if it continues for years, and I should think that it must continue for at least twelve more years, it must certainly pay. For at the present time the waste caused by ignorance of the conditions would more than pay for the expense of investigation. This waste occurs not only in the direct outlay in money of the different mill centres in useless procedures, but as well in useless experimentation, useless discussion, and useless writing. Even if the procedures taken up by the farmers (in collecting and other such operations) are mostly not useless, the money thus spent in one centre is enough to support an investigation of this kind for a year or more. But the collecting operations are too spasmodic to be very useful, and are thus largely wasteful. They must be continuous. They must affect the species most concerned in every centre, not in the one only. It is not yet known that the species most concerned are in every centre. It cannot be known without making an investigation. As regards remedial operations I care to make but very few statements. The problem is untouched from the scientific standpoint. There are a number of likely lines of investigations, and chemistry and mechanics should play an important part in these. The use of parasites—insect, bacterial, or others—is worth consideration, but results from their use will most likely prove disappointing. The increase in the efficient use of carbon bisulphide would seem worth trying. Its application by power machinery after it was proved safe would largely solve the problem. The use of minute quantities of some

powerful animal poison on the soil, to be ingested by grubs, seems worth striving for. The introduction of parasites is worth carrying on, but these should be from countries other than Australia, and it will be necessary to send a man out for them. The effect of the use of manures of vegetable origin may have to be looked into.

Certainly for the present assiduous collecting of the right species as early in the season as possible and throughout the entire season, and the use of the plough during the period of pupation and egg-laying (as much as the general system of farming will allow) are to be strongly urged as wise. But these should be considered as mere makeshifts, a temporary necessity while systematic experimentation and the accumulation of pertinent data are being consistently and continuously carried on.

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