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The Linear Bug, Phænacantha australica Kirkaldy: A New Pest of Sugar-cane in Queensland.

BY

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The Under Secretary,
Department of Agriculture, Brisbane.

SIR,—I have the honour to submit for publication as Bulletin No. 14, Division of Entomology, Bureau of Sugar Experiment Stations, "The Linear Bug, *Phænacantha australica* Kirkaldy, a new pest of Sugar-cane in Queensland," by Dr. J. F. Illingworth.

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

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

The Linear Bug, Phaenacantha australica Kirkaldy: A New Pest of Sugar-cane in Queensland.

Order **HEMIPTERA.** Family **LYGÆIDÆ.**

INTRODUCTION.

DURING September, 1917, I found this species exceedingly abundant in uncultivated forest land on blady grass (*Imperata arundinacea* Cyr.). Sweeping for other insects, I invariably got the net filled with them. And again, in May, 1918, I found these bugs numerous along grassy headlands in some of the cane areas along the bank of the Mulgrave River; later, they simply swarmed over the trash, when the cane was cut in September. 30th August, 1918, I also observed them at Fishery Creek, along the line to Babinda, in which place they were attacking the cane in such numbers that the leaves, especially the older ones, were very yellow; furthermore, there appeared to be a direct relation of the punctures made by the bugs to the various disease-spots on the leaves.

These preliminary observations at once impressed me with the possible seriousness of such a native pest, if conditions ever became favourable for its rapid multiplication at the expense of our cultivated crops. The notorious Chinch Bug of the United States, which belongs to the same family, also originally fed upon native grasses, but, turning its attention to cultivated cereals, the damage in 1874 reached approximately one hundred million dollars; more recently (1904), however, since this pest is practically under control, Doctor L. O. Howard, Chief of the Bureau of Entomology at Washington, has estimated that the nation's annual losses from the depredations of this pest have been reduced to about twenty million dollars.

Though we have availed ourselves of every opportunity to become familiar with the development and habits of this new cane-pest, there is still much to learn. First of all, investigation was seriously handicapped, working, as we are, practically without a reference library. Then, too, we could only give odd time to this subject, since our main energies were expended upon a study of the more important grub-pests of sugar-cane. Yet some information has been accumulated, and, since I am now compelled to discontinue these investigations, I have decided to present this short preliminary paper, hoping that it will be useful to other workers.

I am indebted to Mr. E. Jarvis for making the drawings shown in the two plates.

DISTRIBUTION AND HABITS.

First of all, we were without a name for this bug. No one in Australia was able to identify it, so I sent specimens to the British Museum. There I was only able to secure the name of the genus. I then (11th July, 1919) sent some material to Mr. O. H. Swezey, entomologist of the Hawaiian Sugar Planters' Association, who fortunately found that it was one of the numerous species of bugs collected by their investigators in Australia several years ago. The late G. W. Kirkaldy

of their staff had named the species; and so far I have been unable to locate any other published reference to it.

This pest is apparently gradually changing its habits, and adapting itself to the ways of cultivation. Where the open forest country is broken up for fields of sugar-cane, it must of necessity take to that crop or migrate. The transition, however, is especially easy where fields are left with grassy headlands, for the young bugs are then assisted in their development. I find that most of our Northern districts are affected, even the newer areas opened up in the scrub. These bugs are particularly abundant at Mossman and in the Cairns district, and I have found them also attacking sugar-cane as far south as the Herbert River. Yet for some unaccountable reason they do not appear to be in the sugar-growing districts of the Lower Burdekin, though the well-known leaf-hopper (*Perkinsiella saccharicida* Kirk.), a bug whose feeding habits are much the same, is found there.

The habits of the linear bug are remarkably like those of the chinch bug. It hibernates in bunches of grass and trash; its eggs, too, are very similar, and they are scattered about in the same way, on the soil at the roots of grasses; and, fortunately, it suffers the same natural checks.

The young nymphs only do well, apparently, when they have an abundant covering of grasses in which to develop; the older nymphs, however, climb up into the cane and there feed with the adults on the under side of the leaves. Each of these insects, as will be seen (Plate II, fig. 1), has a mosquito-like beak, by which it easily punctures the epidermis of the leaf and sips at the sap of the living cells. Like all sucking insects, the beak is composed of several parts. These were separated so that they might be shown in the illustration. Normally the labium (*li*), which serves as a tube for sucking, encloses the needle-like mandibles (*m*) and the maxillæ (*mx*); the mandibles working in and out through the tip of the labium pierce the tissues of the leaf, so that the sap may be extracted. A *camera lucida* sketch (*t*) of the tip of one of the mandibles, magnified about 500 diameters, shows that it is constructed on the principle of the ordinary bread-knife, which explains the ease with which the punctures are made.

Normally the bugs feed on the under surface of the leaves, where they are more or less protected, being in the shade and out of the rain. When hungry, a bug will continue feeding, even when under observation of a hand-lens; from time to time the position is shifted, a new puncture being made in each location. Hence it is not difficult to understand the tremendous drain that myriads of these bugs have upon a cane-plant—a subject which will be dealt with in detail further on.

LIFE HISTORY.

Apparently the life-history of this species has never been worked out, and unfortunately I have not been able to give sufficient time to complete this phase of the subject. We do not yet know the duration of each of the five nymphal stages, how long the adults live, or how many

eggs they produce, &c. The first and second nymphal stages are so similar, that for some time I thought there were only four stages, as in the case of the related chinch bug. I experienced considerable difficulty in the rearing experiments, the very young nymphs dying suddenly after three or four days. The cages used in this work were glass cylinders, corked at one end to hold a tiny, living grass-plant, which was to serve as food; the other end of the glass was covered with cheese-cloth, to admit air. The corked end of the tube was then placed in a dish with a very little water, so that the roots of the grass were kept moist and the plant continued growing. I was somewhat more successful with the young nymphs, however, when I supplied them with diluted honey, placed in tiny droplets on the grass-blades. I frequently observed them sipping at this food. Apparently death was usually due to the excessive humidity, which collected in droplets on the glass from the transpiration of the plant.

Oviposition.—Considerable search was made for the eggs before we were able to locate them. During 1918 Mr. Girault gave some attention to the problem, but did not succeed in locating any eggs or even finding the nymphs. It is evident now that his investigation began too late (October), after the bugs had ceased laying. He found the adult bugs in considerable numbers on blady grass, 30th October; though none were seen mating, ten were collected and placed in a cage with a living cane-plant, so as to observe their ovipositing. These lived from ten to nineteen days, but no eggs were deposited.

We have never observed mating pairs or nymphs in the field during the months November, December, and January, though the adults are fairly common, both in native grasses and in sugar-cane.

29th May, 1920, I found the bugs abundant, with nymphs in all stages of development, in a canefield that was full of grass near Meringa. The youngest bugs were in the grass and on the surface of the soil at the roots, but no eggs could be located. I thought it probable that this species would deposit its eggs at the base of the grass-stems, near the soil, as is the habit of closely related bugs. The youngest stage—apparently just hatched—was invariably found in such locations. Dissecting the mating females, I found mature eggs. Each insect had only about three fully developed eggs with several in various younger stages. The ovaries were exceedingly soft, and so transparent that I experienced considerable difficulty in separating them from the insect and floating out the egg-tubes, so that I could make the *camera lucida* sketch for the drawing shown in Plate II, fig. 3. I could make out five separate egg-tubes in each ovary, each with a large egg and usually another just starting. Numerous nuclei could be made out in each germarium (the pear-shaped bodies above the eggs), suggesting the possible fecundity of this species, since the eggs originate from these nuclei. The mature eggs I also sketched with the *camera lucida*, to get exact proportions.

With this information, on 4th June, I made a further careful search

at the roots of grasses, in a badly infested canefield along the banks of the Mulgrave River. Many young nymphs were in evidence, as on the former occasion, but I could not locate eggs on the grasses. When I searched the surface of the soil I found eggs at once—both fresh ones and empty shells. They were, as I suspected, just lying about unattached. Bugs that I had put into a small cage with a growing grass-plant a few days before were dead because the soil had become dry; but two eggs were found on the surface. These were placed in a moist chamber to see if they would hatch. A fortnight later the young nymphs were found dead, because the chamber had dried out.

On 10th February, 1921, I again made a search for the eggs in the field near the Mulgrave River, where I had previously found them. The nymphs were already abundant, and in all stages, though they do not usually come forth in such numbers before April. I found empty egg-shells on the surface of the ground, under thick grass, also young nymphs in various sizes. The adult bugs were mating on the cane-leaves, and I saw many adults in and under the grass.

17th February I placed a number of mating pairs in gauze cages with growing grass-plants, to secure eggs. They began laying at once, and I invariably found the eggs lying about on the surface of the soil under the plant. Ants (*Pheidole megacephala*) got into the cages and played havoc with both eggs and the adult bugs; I saw them in the act of dismembering one of the last of the living bugs.

The Egg.—The freshly laid egg is amber in colour, but it darkens slightly as the nymph develops, and after about a week the red pigment of the eyes, &c., begins to show through the egg-shell. The egg has a long-oval form and is approximately 1·75 millimetres in length. It is noticeably flattened, and has three distinct aspects—front, back, and edge. At one end there is a cap, which is tilted to the front side; this bears a circular row of short spines, irregularly placed, most of them being located at the front. The surface of the shell is shining and dry, with no indication of gum or other covering or means of attachment. The time required for the egg to hatch appears to vary somewhat, but of the few studied this averages ten to twelve days. Freshly laid eggs of 18th February developed eye-spots on 24th February, and hatched 2nd March—twelve days.

The Nymph.—The linear bug, as has been intimated above, passes through five nymphal stages. The bugs of the first two stages are so similar that they can only be definitely separated by constant observation on their moulting and development. This I was able to do, though I did not succeed in keeping any of these very young nymphs alive much more than a week. The other three stages are quite distinct, and can easily be sorted from those collected in the field. The tiny wing-pads and the dusky colour begin to show in the third stage.

First Nymphal Stage.—The newly hatched nymph is pale greenish yellow, with a pair of irregular stripes on each side, and the eyes vermilion; the two dorsal stripes are united midway of the abdomen

forming a rather irregular cross-band, and continued to the dusky pygidium as a median dorsal stripe; the ventral stripes gradually become defused as the nymph develops, appearing more in the form of separate blotches of colour. The form resembles that of the adult, but the tarsi have only two segments, and the head is relatively larger and more rounded; the body is compressed laterally and tapers more rapidly tailwards. The antennæ are large and conspicuous, being almost double the length of the insect; their colour is rich brown, the first segment being reddish, and the proximal portions of the second, third, and fourth, and the tip of the last segment, are white. The legs are very pale yellowish brown in colour, with a touch of vermilion on the distal portion of each femur; the second tarsal segments are dusky. The size when hatched is approximately that of the length of the egg, 1·75 millimetres. The body soon assumes a more normal, rounded appearance, and increases to about 3 millimetres in length before moulting, with antennal segments, beginning at the base, ·75, 1·00, 1·30, and 1·75 millimetres.

Second Nymphal Stage.—After the first moult the appearance is scarcely different, but the body gradually becomes more compressed dorso-ventrally and the proximal segments of the antennæ are lighter at the base. Before moulting, the length of the body increases to about 4·50 millimetres, and the antennal segments to ·95, 1·50, 1·90, and 2·10 millimetres.

Third Nymphal Stage.—After the second moult the thorax is dusky with a median dorsal line and the borders of the sclerites paler in colour. In this stage there is a first suggestion of the wings, which appear as very tiny pale-whitish buds. The length before moulting increases to 5·50 millimetres and the antennal segments to 1·05, 1·80, 2·10, and 2·80 millimetres.

Fourth Nymphal Stage.—After the third moult the thorax and neck are quite dusky; the median dorsal line terminates in a pale-whitish, obtuse spine between the wing-pads; the latter are fleshy in appearance and usually have a dusky, small spot in the centre of each. The vermilion stripes are more defused, especially below. The first, second, and third segments of the antennæ are lighter in colour, except on the distal portions. Before moulting the length increases to about 6·50 millimetres and the antennal segments to 1·40, 2·00, 2·30, and 3·00 millimetres.

Fifth Nymphal Stage.—After the fourth moult the head and thorax are quite dusky-black, the latter covered with a very fine, grey pubescence. The coriaceous wings are also dusky, especially at the base and a spot in the centre of each. The dorsal spine is acute and conspicuously whitish in colour, in marked contrast to its darker surroundings. The abdomen is practically all red below. Before moulting the size may increase to 8 millimetres and the antennal segments to 1·40, 2·00, 2·30, and 3·00 millimetres.

Adult Stage.—The change in size from the last nymphal stage is not noticeable, and the general colouration is maintained. The thorax

is finely punctured and leaden in colour, except the posterior lobe of the pronotum and the basal portion of the scutellum, which are velvety in appearance and black or tawny in colour. The hind border of the scutellum has a narrow pale-whitish edging and terminates in an erect, acute, median spine of the same colour but darkened on the apical third. The legs are darker than in the nymphs, but without the vermilion; the tarsi have a median segment not found in the developing stages. The antennæ and head are distinctly paler in colour, and the eyes are more prominent. The abdomen is a duller red, dusky at the base, especially below, and has a pale greenish yellow line extending along the lateral margins. The wings extend almost to the tip of the abdomen, and are hyaline with brown veins.

INJURY TO SUGAR-CANE.

These sucking insects, when abundant, are commonly seen during the day sitting about on the under side of the leaves of sugar-cane. By careful approach it is easy to observe that most of them have their beaks inserted into the tissues of the leaf. Indeed, so intent are they usually at their feeding that one may observe them with a hand-lens, and I have even touched them in some instances before they would move away. When not feeding, however, they took flight as I approached within 3 or 4 feet, and it was not unusual to see them going in droves before me as I walked through the trash just after the cane was cut.

Naturally the feeding of such an army of bugs is a serious drain upon the manufactured sap of the plant, so it is not uncommon to see the cane of badly infested fields gradually assume a yellow colour, and, later, various fungous diseases frequently appear on the leaves. The punctures made by the bugs, though too small to be seen with the naked eye, are exceedingly numerous, for each individual is constantly making new ones, as he probes for the sweet juices. These injured areas soon become lighter in colour, followed by yellow, and finally this colour is replaced by red or brown where disease germs have entered.

I have noted on various occasions what appeared to be a direct relation of these bugs to fungous attack on cane-plants. A most marked instance was a field of young Badila, on the flats along the Mulgrave River. When an old ratoon field across the headland was cut the bugs simply swarmed into this young plant cane, which was only about 2 feet high; most of the leaves were soon blighted, and many of the shoots became diseased. This malady appeared to be Tip-wither, for the sick leaves had all the characteristic markings described by Doctor Cobb in his bulletin "Fungus Maladies of the Sugar Cane."* The effect was much worse in the rows next to the grassy headland, and it appeared less and less as I went further back. In fact, it was difficult to find a trace of it after the tenth row. I was interested, too, to observe that the diseased cane exactly coincided with the distribution of the bugs in this field, so it left no doubt in my mind that they were directly responsible for the trouble.

* Hawaiian Sugar Planters' Assn. Div. Path. and Physiol. Bull. No. 6.

In other districts, too, I have frequently observed the same distribution of the bugs with relation to grassy headlands, or along tramways and ditches where grass was permitted to grow. Even in the humid area at Babinda I have seen cane evidently suffering in fields that adjoined grass-land, the leaves being quite dry in places, and even the topmost ones very yellow.

These bugs work so insidiously, leaving no apparent devastation upon the plants injured, that the average individual would hardly realise that any serious depredation to his crop was going on. Yet, if such insects multiplied unrestrictedly, they might easily remove the sugar content to such an extent that the cane would hardly be worth cutting. This was what happened in Hawaii, when our common leafhopper (*Perkinsiella saccharicida*) was accidentally introduced there without its natural enemies. A similar species, *Peregrinus maidis*, too, sometimes destroys the corn crop, even before it comes to ear, drying up the leaves, and making them sticky with the honeydew that is continually excreted.

Hence, knowing something of the activities and feeding habits of such insects, it is not difficult to realise the drain that even moderate numbers of these bugs make upon our crop. Where they cause the cane to turn yellow, the c.c.s. is undoubtedly reduced materially—possibly a ton or more of sugar per acre.

The work of the linear bug is more noticeable in some varieties, especially Clark's Seedling and Badila—D1135 being little affected. This was very marked where the varieties were growing in adjoining blocks at Meringa.

NATURAL ENEMIES.

Unfortunately, we have not been able to give much time to a study of these controlling factors. The eggs, being so exposed, are probably destroyed in great numbers by both parasites and predators. I have already referred to the ants, which not only carried off the eggs, but also destroyed the adults, during our breeding work. Several other predators have also been observed, but probably the most important natural check upon their multiplication is an undetermined fungus, which causes a disease among the bugs during humid weather.

The fungous disease has been particularly noticeable in the rainy districts, just as one might expect; so these pests will probably not be much of a menace under such conditions. The dead bugs frequently remain sticking to the leaf, right where the disease overtook them, and their hardened bodies are covered with a grey coat of the mycelium of the fungus. A rather important enemy is a large, predaceous, Reduviid bug (*Pristhesancus papuensis*), which is generally found wherever this pest is abundant. The eggs of this predator are deposited in clusters on the leaves of sugar-cane, where Mr. Dodd found them attended by a parasitic Chalcid (*Anastatus* sp.).

At the roots of the grasses, where much of the early life of the pest is spent, predators appeared to be particularly active. I have observed

the ants dismembering the bugs there; overpowering them by superior numbers, holding to the legs, antennæ, &c., while their soldiers cut off the appendages, leaving the bugs helpless, to be carried off piecemeal. The Reduviid predators were also found in these locations, where it was observed they had no difficulty in securing their prey.

Studying the pest briefly at the South Johnstone Experiment Station, where the bugs simply swarmed in the cane, during October, 1920, few death-factors were apparent. These were principally spiders and the omnivorous ant, referred to above. Since the field examined adjoined the scrub, the cane had numerous webs of the ordinary showy crab-spider, and in several instances I found that they had eaten the bugs. I also saw a green jumping spider spring upon one of these pests. No indication of the fungous disease was observed, probably because the weather had not been suitable.

CONTROL MEASURES.

Since the young bugs require a grassy bed in which to develop to the best advantage, the obvious control is clean culture. Grassy fields, with grassy headlands, are usually the ones seriously affected. Hence good cultivation usually gives these bugs a real check by destroying the hiding-places for the eggs and young nymphs.

Another important controlling factor is fire. Grass paddocks adjoining cane areas should be burned as early as possible in the dry season, at the time that the young bugs are beginning to thrive; this will destroy them in countless numbers, and few will escape to enter the cane, if the fields, too, are kept free of grass. Though I deprecate the burning of trash as a general practice, it may be advisable under some circumstances to clear out the bugs in this way, where they occur in hordes at the beginning of the cutting season, in June or July; for this may save considerable injury to nearby crops.

Spraying with arsenite of soda for the destruction of grass and weeds will probably also have a beneficial effect in controlling the bugs. Certainly any that were hit by the poison would be destroyed, and the very young stages could hardly withstand the drying up of their food supply. Yet it is a difficult matter to forecast the result of such a procedure. In Hawaii it was found that the leafhoppers were more abundant on plantations where weeds were controlled by spraying than where chipping was done. Investigation finally showed that the natural enemies of the leafhoppers were destroyed by the poison, so that the pest was permitted to multiply unhampered. Hence it is always advisable to experiment before interfering too drastically with Nature's workings.

SUMMARY.

My first experience with the linear bug was while sweeping for other insects during September, 1917, in blady grass in the open forest near Meringa. This species occurred in such numbers that I invariably got the net filled with them. In May, 1918, I first found them in numbers

on sugar-cane at Gordonvale. The field had been rather neglected, grass filling the headlands and ends of the rows. The bugs were so plentiful that when the cane was cut they simply swarmed over the dry trash.

Since this pest belonged to the family Lygæidæ, and had habits similar to the notorious chinch bug of the United States, I recognised that there was possibility of its doing considerable damage to sugar-cane if unrestricted in its development.

Their distribution, as far as I have been able to observe, is from the Herbert River district north to Mossman. For some unaccountable reason they do not occur in the dry districts on the Lower Burdekin.

The eggs are naturally deposited at the roots of grasses and the young nymphs feed under this protection for a time; hence, where they have been found to occur in sugar-cane, grass was found, either in the cane or near by.

The bugs occur throughout the year, though mating apparently only takes place during the drier season. I have found nymphs from the 10th February to 29th October.

On sugar-cane, these bugs sit on the under side of the leaves, where they usually have their beaks inserted, sipping at the sweet juices. The myriads of microscopic punctures thus made soon cause the leaf to become lighter green or yellow in colour, and frequently disease organisms follow, causing the tissues to turn red or brown. The action of this pest is so insidious that the average individual scarcely knows that any injury is being done to his crop. Yet, if unrestricted in their multiplication they might easily remove the sugar content to such an extent that the cane would hardly be worth cutting. Even in the numbers that they now occur in some fields, they probably lower the c.c.s. so that there is a serious loss—possibly a ton or more of sugar per acre.

These bugs are evidently fairly well held in check by natural enemies, else they might take our crops. In the humid districts, and sometimes during the rainy season elsewhere, they suffer from a fungous disease, which possibly is an important factor in holding them in check. Several predators have also been observed, the most abundant being the omnivorous ant (*P. megacephala*) and a large Reduviid bug. Search will probably reveal egg parasites and other predators.

I would suggest clean culture as the principal control measure. Keep headlands ploughed and grass out of the field; adjoining grass paddocks should be burned as soon as they become dry enough. In this way the young nymphs may be destroyed in great numbers during May or June. Then, too, where the bugs occur in great numbers at the time that the cane is ready to cut it may be advisable to burn the trash, in spite of its recognised value as a supplier of humus.

PLATE I.—Various Stages in the Life-history of the Linear Bug (*Phœnacantha australica* Kirkaldy).

Fig. 1.—The mature insect ; X7.

Fig 2.—The same ; nat. size.

Fig. 3.—Wings of the same ; X12.

Fig. 4.—The egg : *a*, front view ; *b*, back view ; and *c*, edge view.

Fig. 5.—Nymph, second stage ; X7. The first stage is very similar in appearance, except that the abdomen is narrower.

Fig. 6.—Third stage of same ; X7.

Fig. 7.—The fourth stage ; X7. The fifth stage is similar to the adult in form, except the wings.

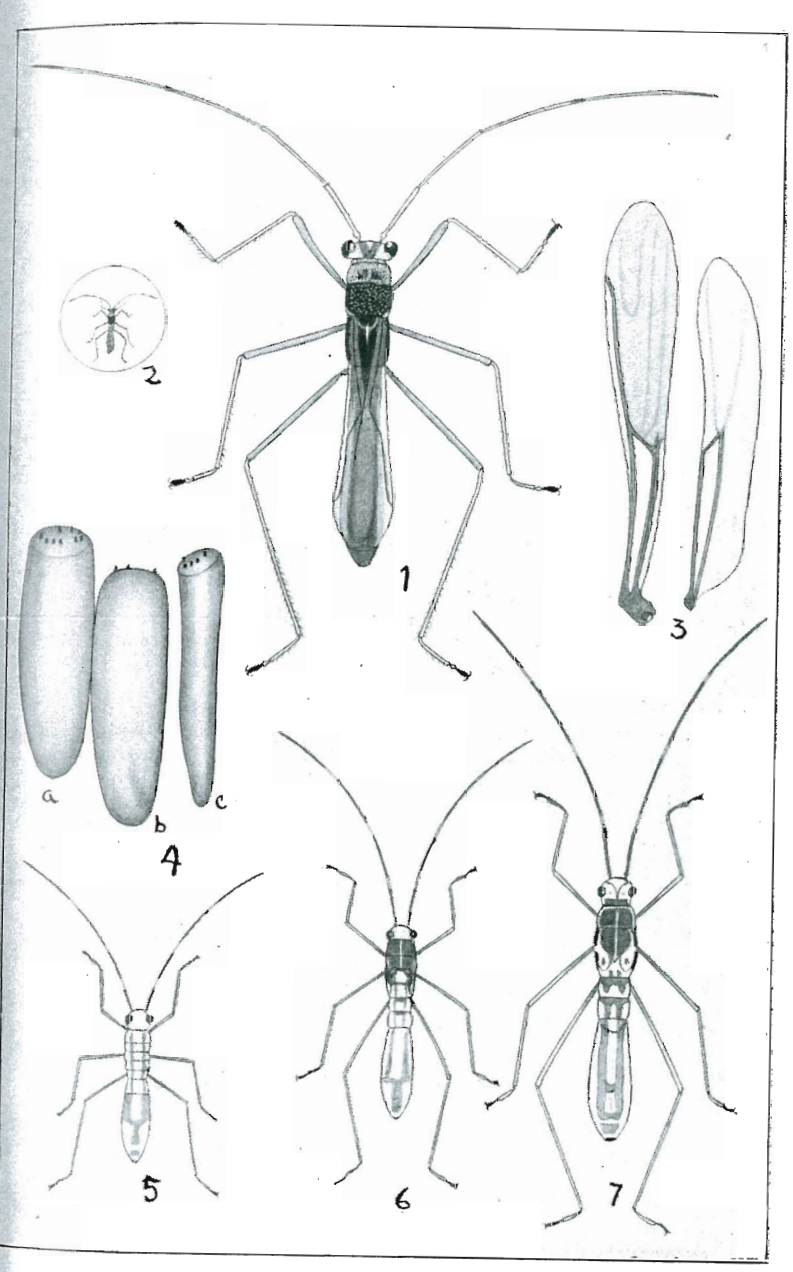
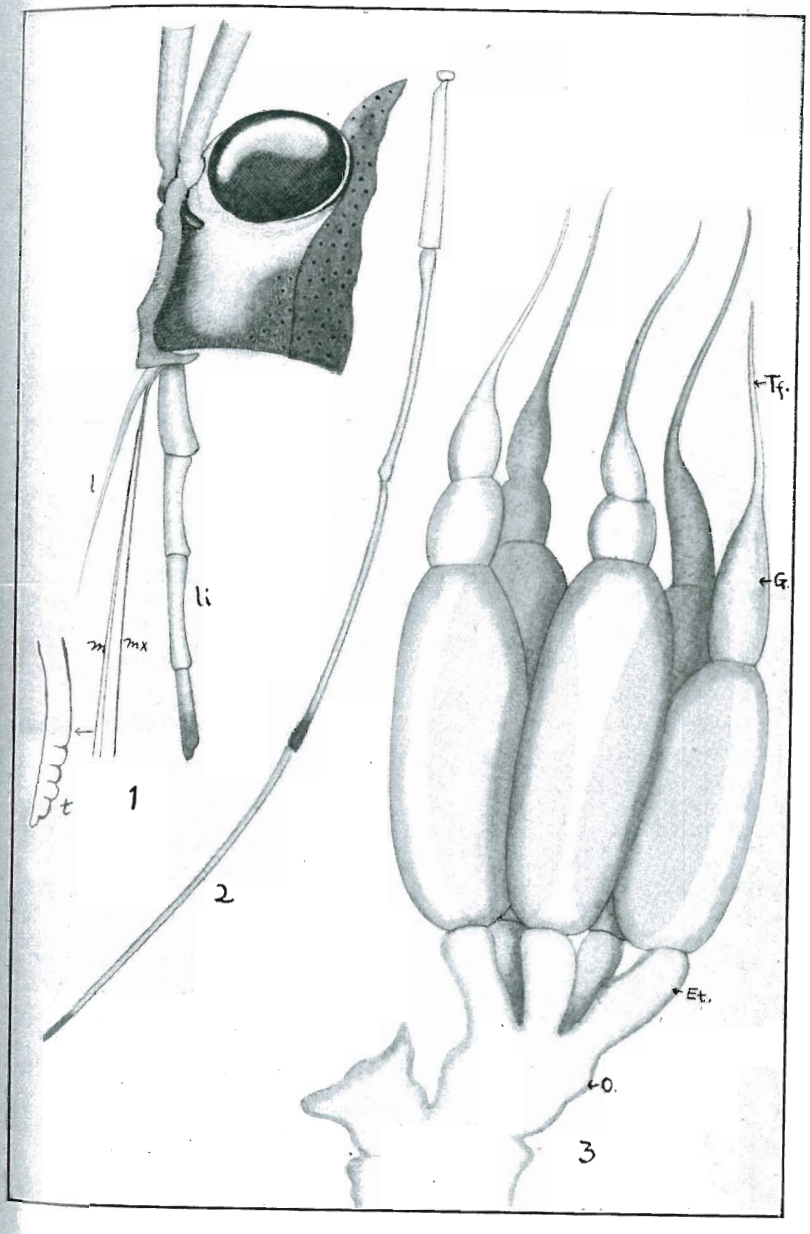


PLATE II.—Anatomical Characters.

Fig 1.—Head; showing mouth-parts; X40; *l*, labrum; *li*, labium, which serves as a tube for sucking; *m*, the two needle-like mandibles, which are used for piercing the leaf; *t* shows the appearance of the tip of one of these when highly magnified; *mx*, maxillæ. The needle-like parts have been removed from their normal position, within the labium, so that they could be shown in the drawing.

Fig. 2.—An antenna; X20.

Fig. 3.—An ovary; showing the five egg-tubes, and their structure; X45; *O*, oviduct; *Et*, egg-tube; *G*, germarium; *Tf*, terminal filament.



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