AN INVESTIGATION OF THE RAT PEST PROBLEM IN QUEENSLAND CANEFIELDS: 1. ECONOMIC ASPECTS.

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SUMMARY.

1. *The fragmentary published records of rat damage to sugar cane in Queensland prior to* 1935 *are reviewed and evidence of rat damage collected since that year is presented. Appreciable rat attacks are shown to occur only periodically and usually sporadically.*

2. *An account is given of the form of rat damage to cane, and it is shown that the damage often is of the nature of a nuisance, in that there is interference with harvesting and with general farm routine.*

3. *The various factors contributing to economic loss are discussed. It is concluded that usually not more than one unit of C.C.S. (sugar content) is lost in cane harvested from fields subjected to heavy and continued attack, and that actual cane tonnage losses are seldom high. The imposition of penalty harvesting rates often converts the nuisance factor into an economic loss to the farmer.*

INTRODUCTION.

Rats and other rodents have been reported from many parts of the world as field pests in agricultural, pastoral, and allied industries. Much has been written on this subject but the control of field rats is still far from satisfactory.

So far as the rat pests of sugar cane in Queensland are concerned few records of a detailed nature were published prior to 1935; this does not mean that these pests were absent, nor that they were neglected entirely, although it is perhaps a reflection of the status of rats as pests prior to that date. From such earlier references as are available it would seem (as has been the case during the past ten years) that appreciable rat attacks on cane crops occurred only periodically and usually sporadically. Earlier published references to the problem are rather fragmentary, since observers were usually associated with sugar mills or with organizations that did not normally publish the results of their efforts, which in any case were seldom continuous and were mostly concerned with the experiences of the moment and not with the provision of data for the guidance of future investigators. These almost purely topical references should therefore be viewed in perspective and should not be accepted without due

reservations; such as are here referred to have been cited in the text and have not been included in the formal list of references.

In the second volume of *The Australian Sugar Journal* (1910, p. 269) mention is made of the varieties of rats found attacking sugar cane, and later in the same year (*ibid,* p. 367) the depredations of the pests were discussed by the Johnstone River Canegrowers' Association; and subsequently (*ibid,* p. 429) various rat poisons and methods of baiting were recommended by Mr. C. E. Jodrell, a prominent cane grower. In the issue for July, 1911 (p. 225), it was recorded that rats descended upon the Lower Burdekin district in thousands, while they were reported to be numerous at Gordonvale in 1915 (*Aust. Sugar J.,* 1916, p. 737).

In 1920 the Bureau of Sugar Experiment Stations initiated a system of district inspections by a very small staff of travelling officers, non-technical reports of the inspections being published in *The Queensland Agricultural Journal* and *The Australian Sugar Journal* from 1920 till 1932, when this system was discontinued. From a study of such reports it is apparent that in 1922 rat damage in North Queensland was much more severe than usual, especially in the Mulgrave and Herbert River areas. The next two years evidently witnessed a decline, but in 1925 damage was again reported as being severe in the far northern cane districts. Considerable damage was reported at Tully and in the late-harvested cane at Ingham, in 1927, but otherwise only light infestations were reported from northern, central, and southern cane districts during the period 1926-28. No specific mention is made of the incidence of the pests over the years 1929-33, but in the June, 1932, issue of *The Queensland Agricultural Journal* (p. 299) Kerr summarized the then existing knowledge of rat control in canefields and referred to poisoning campaigns then being carried out by North Queensland Cane Pests Boards.

The year 1934 saw the commencement of a distinctly new phase in the investigation and treatment of the rat problem in Queensland canefields. Kerr (1934), referring to the state of the crop in the more northern areas, stated:— "A large percentage of the crop was damaged by rats, grubs, and borers"; while Bell (1934) recorded that "damage to cane on account of the attack by rats has been considerably greater than in previous years and in the aggregate has been greater than that caused by any other pest." Gard (1935), in a summary of the rat problem in the Macknade Mill area (Herbert River) for the years 1930-34, indicated that rats were prevalent there during 1932, 1933, and 1934.

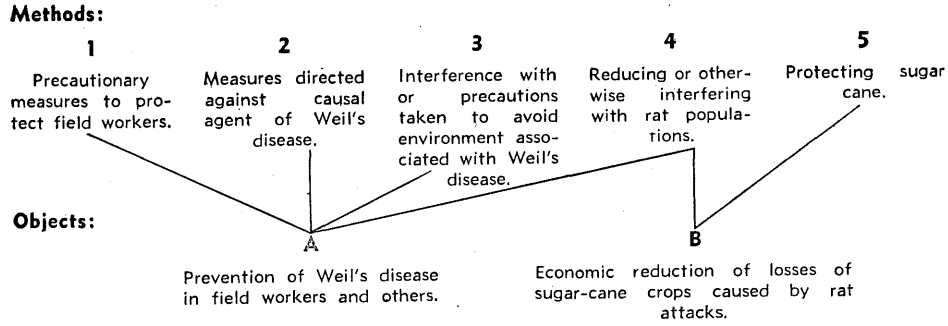
At this time, also, the importance of the rat control problem was increased by an outbreak of Weil's disease in the Herbert River district. Morrissey (1934) has recorded that in October, 1933, there appeared the first reported series of cases of a disease which was later diagnosed as Weil's disease. Laboratory and epidemiological investigations by Cotter and Sawers (1934) demonstrated the relationship between the causal agent (*Leptospira icterohaemorrhagiae* Inado and Ido) of this disease and rats in canefields, and particularly noted the

incidence among cane cutters and also among cane growers whose exposure approximated that of cane cutters. Thereafter, the prevention of Weil's disease became part of the rat control problem of certain North Queensland sugar-cane districts and one immediate result was the institution by State Health and Medical Services (Cilento, 1936) of a comparatively large-scale anti-rat campaign in the Herbert River district; this campaign was continued for two years.

In the past rats in canefields have been considered of minor importance, except in certain exceptional years which, in most instances and in all districts, have been well spaced. Interest in these pests has been sustained, in the face of declining crop losses, mainly as a result of the association of field rats with the transmission of Weil's disease.

In 1935 the author was assigned to special rat investigations, the undertaking of this work being preceded by a period of special study of rodent zoology at Sydney University. Progress reports of certain phases of this investigation have been published from time to time (McDougall, 1935-40), while Bell (1935-40) has given summarized accounts of the yearly depredations of the pest and of investigational work carried out by the Division under his control. Reports on the medical aspects of the problem and the concomitant industrial repercussions have been made by Cotter (1935), Cilento (1936), and Sawers (1938). Extensive topical references may be found in various sugar journals, while certain aspects have been debated annually by conferences of Cane Pests Boards functioning under the provisions of "*The Sugar Experiment Stations Acts,* 1900 *to* 1941."

The scope of investigations carried out in Queensland during the past ten years may be represented schematically as under:—



According to Cilento (1939):

" . . the rat menace and the leptospirosis problem are associated with particular localities, and sometimes with very restricted areas. Leptospirosis, in fact, is a focal disease.

"Cases of leptospirosis have occurred in several instances in the same groups and on the same farms in successive years. They have several times occurred significantly when lowlying ground is being cut, and have usually, but not always, been accompanied by a fairly heavy rat infestation."

It would seem, therefore, that a superimposed but restricted environment has broadened the rat problem in only a few localities. The investigation undertaken by the author has been concerned primarily with object "B" above. Studies such as those on rat populations and their behaviour in the field have also a medical interest. Nevertheless, in this series, only deductions directly and strictly concerned with the geographically wider agricultural aspect have been considered.

The Form of Rat Damage to Sugar Cane.

Rats damage sugar cane primarily by gnawing the stalks at night. As a rule the rind of any one internode is broken in one distinct place only (Plate 1), and such damage is here termed a rat bite; *i.e.*, the recording of three "bites" on a stalk means that three internodes have been damaged by rats. Actually,

Plate 1.
STALKS OF THE VARIETY BADILA DAMAGED BY RATS.

any particular bite may be the result of more than one rat, feeding for two or three nights, or it might have provided a single rat with but a part of its nightly intake. Field cage experiments have shown repeatedly that a large bite may be the work of one small rat over two or three nights or that of several young rats during a single night. Also, a large rat may start a number of bites during the first night and these may be enlarged by it, or by others, during that or succeeding nights.

Rats are wasteful feeders and associated with their bites there is usually some finely chewed cane tissue or frass, either scattered or in loose piles. Under certain conditions in Queensland several other indigenes—such as opossums (*Trichosurus* spp.), rat-kangaroos (*Potorinae*), wallabies (*Macropus* spp.), the eastern swamp hen or red-billed coot (*Porphyrio melanotus* Temminch), and the brush or scrub turkey (*Alectura lathami* Gray)—attack cane stalks in a somewhat similar manner. However, the form of damage is usually distinctive. For example, in the case of the turkey the scored cane tissue shows distinct beak marks; many of the marsupials damage the growing parts of stalks also, and they often leave some of the discarded but chewed stalk tissue in loosely cohesive lumps.

The number of bites on any stalk may be as many as the number of uncovered internodes; the attack may be near ground level and/or higher up the stalk. Sometimes only a few stalks, in stools scattered here and there throughout the field, may be attacked; on other occasions fields of pure stands of any variety may receive the attentions of the pests either throughout the fields or in irregular patches. Often it is lodged cane which is chiefly damaged, but it may be cane growing in those parts of the fields near creeks or other watercourses, around seepages or swamps, or close to ground cover (shrubs, weeds, and grasses) or "scrub" (rain forest); occasionally cane near buildings is selectively damaged by rats. However, it does not follow that all cane in these situations will be attacked by rats: this is far from fact even in years of large and widespread rat populations. When "supplies"* of a soft variety like H.Q.426 or H.Q.285 are planted in a field of a harder variety such as P.O.J.2714 or P.O.J.2878, the stools of the supplies are sometimes completely eaten out, while little or no damage is inflicted on the harder cane. Similarly, rows of softer varieties planted near or amongst harder canes, or only fields of more susceptible canes, may be selected for attack.

In the northern and central areas, the cane is planted from autumn to late spring, the resultant crops being harvested during the latter half of the succeeding year; it is only in exceptional circumstances that two-year crops are grown in these areas. Rat attack normally commences during the colder weather† in June and July, and continues until November at the latest. Occasionally damage is observed as early as May, some species of rats having a

* *I.e.*, replants of cuttings which have failed to germinate.

† It is of interest to note that, in a personal communication dated 20th November, 1936, received from D. H. Doggrell, a State forestry officer stationed at Imbil, South Queensland, it is stated that rat damage in reforestation areas is confined to the winter months.

tendency to attack cane earlier than others. Occasionally, also, there occurs "out-of-season" damage; as, for example, when small patches of cane are surrounded by water for some time during the rainy season and then temporarily harbour concentrated rat populations quite abnormal for that time of the year; or again when small isolated blocks of cane are left standing late in the harvesting season on rat-infested farms. Within the normal period of rat attack there may be considerable variation in time of infestation in different years. Depending upon current conditions, attack may commence at any time during this period, perhaps early August or even October, and either continue unabated till the end of harvesting or gradually decline.

Cultivated young cane is seldom attacked by rats, and it is often stated that crops are attacked only when and because the sugar content begins to rise. This idea has doubtless developed because it so happens that early-maturing canes such as H.Q.426 and H.Q.285 are soft canes and therefore "rat susceptible"; this applies also to N.G.15 (Badila) and S.J.2, both canes of high sugar content. On the other hand the less widely grown P.O.J.2725, 7R.428 (Pompey) and Co.290, if grown in suitable localities, are attacked by rats early in the winter, and early maturity and high sugar content are not characteristics of these varieties. No characteristic of the cane itself (*e.g.*, sugar content or maturity) has as yet been correlated with the time of occurrence of a mid- or late- season rat attack.

The visible effects of rat attack on sugar cane are usually very obvious (see Plates 2, 3, 4 and 5). So far as is known rat attack on sugar cane in the field does not influence the quality of sugar eventually manufactured. With some slight adjustment, depending on harvesting methods, cane payments to the farmer are made on the basis of cane weight and sugar content and for the purposes of assessing magnitude of economic losses usually these factors only are taken into account.

The Assessment of Economic Losses Caused by Rats.

Pemberton (1925) reported the losses due to rat damage in Hawaiian canefields. These careful estimates were based on comparative analyses and weighings of rat-damaged and non-rat-damaged cane stalks, together with an allowance for dead cane left in the field after harvesting. The estimated loss of 19·17 per cent. (in tons of sugar) of the potential crop on two plantations in 1922 was considered by Pemberton to be vastly more than would have been estimated in the absence of such analyses. It is reported from the same source that further studies, conducted on similar lines, amply confirmed these earlier results. In another series of analyses comparatively slightly damaged cane—only one to three bites per stick—was sampled, and even here crop loss (weight $\times$ sugar content) was found to be 14·9 per cent.

Gard (1935), using methods somewhat similar to those reported by Pemberton in Hawaii, estimated losses due to rat damage in the Macknade Mill

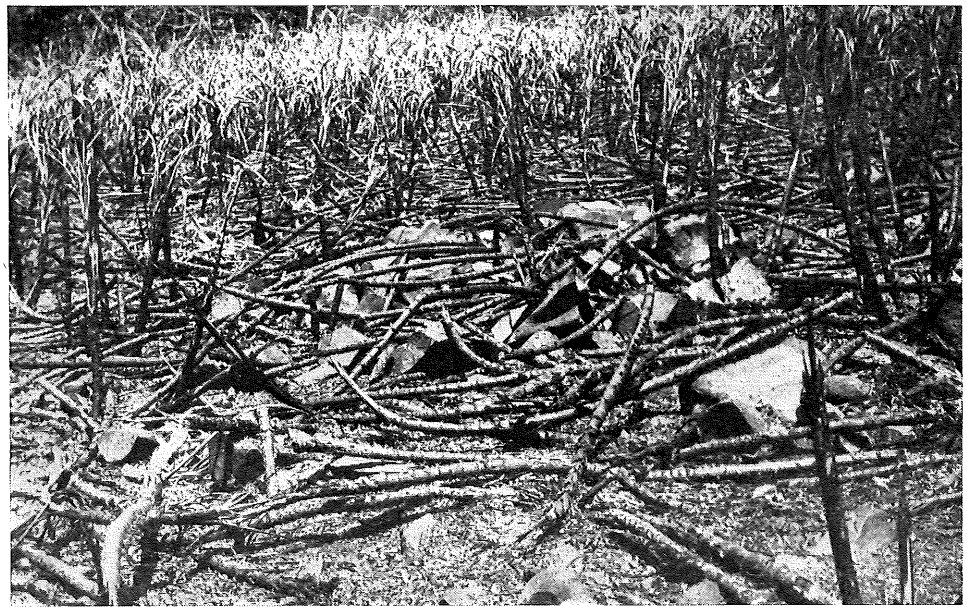


Plate 2.
THE VARIETY BADILA AFTER RAT ATTACK AND PRE-HARVEST BURN.

Plate 3.
ANOTHER FIELD OF THE VARIETY BADILA, GROWN ON STONY GROUND IN THE FARLEIGH MILL AREA (MACKAY), AFTER RAT ATTACK.—This field was not harvested in a year of excess production.

Plate 4.

A FIELD OF THE VARIETY P.O.J.213, IN WHICH 98.5 PER CENT. OF STALKS WERE DAMAGED BY RATS.—Photographed after burning of field.

Plate 5.

A RAT-DAMAGED FIELD OF THE VARIETY P.O.J.213 AFTER PRE-HARVEST BURNING.

area to be 8 per cent. on the 200,732 tons of cane crushed during 1933, a season of heavy rat damage. This loss was made up as follows:—

	Per cent.
Loss in weight of harvested cane due to rat damage	5.5
Loss due to deterioration in damaged cane (*i.e.*, loss in sugar content)	1.5
Loss due to damaged cane being discarded in the field ..	1.0
Total	8.0

Comparing the magnitude of this damage with the higher figures reported by Pemberton, Gard points out that the greater age of the cane at harvesting in Hawaii must be taken into account. In this connexion Barnum (1930) states that investigations at one Hawaiian sugar plantation indicated that both rat and borer damage increased rapidly after the canes were 16 months old.

The yearly fluctuations in percentage of stalks damaged by rats and in percentage loss in weight of cane delivered to the Macknade Mill over a number of years are set out [1] as under:—

Year.	Percentage of rat-damaged stalks.	Percentage loss in weight.
1930	13.0	Not determined
1931	18.7	3.0
1932	23.8	4.2
1933	33.3	5.4
1934	32.8	5.3
1935	19.2	4.9
1936	5.3	1.1
1937	10.9	2.6
1938	10.7	2.4
1939	10.1	2.2
1940	5.6	1.3
1941	5.4	1.2
1942	20 (approx.)	4 (approx.)

In the adjoining Victoria Mill area losses in weight only have been reported [2] for four-year periods as follows:—

1928-1931	14,000 tons of cane,	or 1.6 per cent.
1932-1935	32,500 „ „ „	3.4 „ „
1936-1939	4,000 „ „ „	0.4 „ „

[1] Gard (1935 and 1938-1942).

[2] Aust. Sugar J., Jan., 1940, p. 563.

The percentage of rat-eaten stalks for this area during the period 1934-1938 and for 1940 are given [1] as under:—

1934	14.7
1935	11.7
1936	3.9
1937	3.4
1938	3.2
1940	3.7

In making the above computations the mill area was used as a unit, and samples were taken periodically from the cane delivered to the mill for crushing. The figures include no allowance for damaged cane left in the field.

Owing to the quantitative and qualitative variation of both rat damage and sugar cane from locality to locality, from farm to farm, and from field to field, it is considered that the assessing of losses under Queensland conditions should be made, where possible, with the farm as a unit. This subdivision would permit the readier detection of anomalies as well as indicating the distribution of damage—a point of very considerable economic importance.

Economic losses resulting from rat attack on sugar cane may be considered under the following headings:—

1. Loss in weight of harvested cane;
2. Loss in sugar content of harvested cane;
3. Loss due to interference with harvesting;
4. Loss in field yields as expressed by reduction of cane tonnages;
5. Loss due to interference with general farm routine;
6. Rat control costs.

These are discussed in turn hereunder:—

1. The following are submitted as instances of what may be obtained when attempts are made to calculate loss in weight of harvested cane by comparing the weights of rat-eaten and non-rat-eaten stalks.

(*a*) Two acres of Badila ratoons were harvested early in the season to avoid further rat damage. Counting and weighing of stalks were carried out after the cane had been cut and was lying in bundles in the field. It was found that 55·7 per cent. of the stalks had been attacked by rats, with an average of four bites per stalk; damaged cane had been further attacked by the weevil borer *Rhabdocnemis obscura* Boisd. The total yield of harvestable cane obtained from this field was 35 tons 7 cwt.; equal numbers of damaged and undamaged stalks aggregating 17 tons 5 cwt. were weighed, and it was found that a difference in weight of 1 ton 3 cwt. existed in favour of the undamaged stalks in this large sample. All rat bites were carefully examined and compared with similar bites inflicted under controlled conditions on the same variety, and the actual loss in weight of cane (due allowance being made for drying out)

[1] Aust. Sugar J., Jan., 1939, p. 596, and Jan., 1941, p. 509.

was calculated. It was found that in this sample of 17 tons 5 cwt. the actual loss in weight due to rat bites was of the order of 400 lb. It follows, therefore, that the rat attack was selective, lighter stalks receiving preference.

(*b*) The harvestable cane in a 3¼-acre field of P.O.J.2878 contained 37·2 per cent. of rat-eaten stalks; 95·7 per cent. of such stalks were found to be the smaller-barrelled, lighter type of stalk often encountered in this variety. The undamaged stalks were significantly heavier than the damaged stalks, the ratio of weights being 5·3 : 3.

(*c*) In a 12-acre block of Badila, one acre, in a damp situation adjoining a creek and rain forest, was infested with rats. Within this acre all harvestable stalks (estimated weight 20 tons) were inspected and counted; 53 per cent. were found to be damaged, with an average of 2-3 bites per stalk. Weighing of equal numbers of damaged and normal stalks showed no significant difference in aggregate weights, while the actual loss due to rat bites was of the order of 150 lb.

(*d*) In a field similar to that of (*c*), weights of samples of equal numbers of stalks were recorded as follows:—

Rat-damaged: 235, 135, 140, 157, and 157 lb.
Mean 165 ± 18 lb.
Non-rat-damaged: 167, 107, 127, 177, and 80 lb.
Mean 132 ± 18 lb.

The standard error of the difference between means, viz., 25·6, is not significant at the 5 per cent. level.

Neither rat stalk selection nor losses in weight due to rat attack can be traced statistically by weighings in cane of the type encountered here and in (*c*).

The investigations indicate that it is impracticable to calculate loss in weight of harvestable cane (*i.e.*, cane delivered to the mill) by comparing the weights of rat-eaten stalks and non-rat-eaten stalks. Probably the most obviously incorrect results are obtained when using this method in fields with a very high proportion of damaged stalks. The use of this method assumes that rats attack stalks at random. This has been found to be far from correct (see (*a*) and (*b*) above). In fields where varieties and environment vary stalk selection is obvious; *e.g.*, stools of softer "supplies" or patches of lodged cane may contain the only rat damage in that field. Sometimes a careful inspection of stalks within a typical rat environment may result in the finding of teeth marks on many undamaged stalks. It has been observed that stalk selection by rats is involved, and dependent not only on cane varieties and type of crop and growth but also on the species of rats and the make-up of their populations, on seasonal conditions, and on time of infestation. Furthermore, it seems that, as used, the comparison of weights of rat-eaten and undamaged stalks, as indicative of loss in weight of harvested cane, also assumes that there is little variation in weight between stalks themselves within any particular field. Kerr (1932), discussing

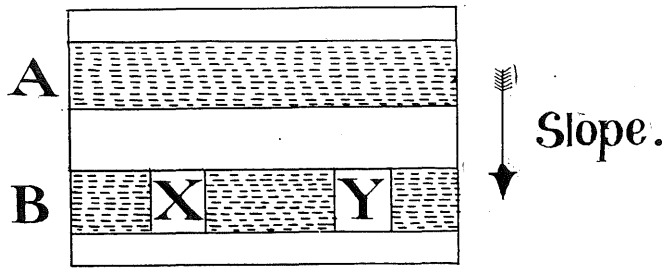
field sampling for the determination of sugar content, remarks that the range of variation of stalk weights was extremely large in fields considered by him. It is common experience that there may be a large variation in weight even between stalks of the same stool. It follows, therefore, that if rats by some possibility did select stalks absolutely at random very careful sampling methods would have to be formulated and used to obtain statistically sound results.

2. The foregoing remarks on the validity of the comparison of weights of damaged and undamaged stalks also apply in principle to comparisons of sugar content. However, there are few records of significant loss of sugar content as a result of rat depredations in Queensland canefields.

Gard (1935) has reported a loss which approximated $2\frac{1}{2}$ units of C.C.S.* in samples of cane in which 50 per cent. of stalks were rat-eaten and which were taken towards the conclusion of the crushing season, *i.e.*, in circumstances where deterioration was likely to be much greater than it would have been earlier in the season.

As a result of numerous analyses conducted by the author it would appear that in Queensland there is less fundamental variation in sugar content of samples of damaged and sound cane, grown in the one environment, than there is in their respective weights. This conclusion is in general accord with the observations of Kerr (1932). Rat-eaten cane frequently exhibits comparatively low C.C.S. content, but this is often due to the environment of the damaged cane. Samples were taken from lodged cane (a frequent indication of a rat-favourable environment) in a 12-acre field of M.1900 Seedling free of rats, and some of these samples were as low at 12·3, whereas the standing cane was milled for a C.C.S. of 16·1.

During 1936 a field sloping from a hillside to a grassy creek was watched for rat damage. Early in June two small areas (X and Y) of the more rankly growing cane near the creek, where rat damage could be expected, were protected from rats in accordance with the layout figured below.



* C.C.S., or Commercial Cane Sugar, is the usual Queensland standard measure of available sugar in cane. It is derived from the empirical formula—

$$\text{C.C.S.} = \frac{3P}{2}\left(1 - \frac{5 + F}{100}\right) = \frac{B}{2}\left(1 - \frac{3 + F}{100}\right)$$

Where P = pol in first expressed juice,
B = brix in first expressed juice,
F = fibre in cane.

At the end of August, C.C.S. samples were taken from A, representing that part of the field not damaged by rats; from B (excluding X and Y), that part of the field damaged by rats (32 per cent. of damaged stalks with an average of three rat bites per stalk); and from X and Y, as examples of undamaged cane from the rat environment. Recordings were:—A 15·3 units of C.C.S., B (less X and Y) 13·3, and X and Y 13·1. When the cane from a field of this type is delivered to a mill it is probable that the farmer would consider rat attack had lowered C.C.S. by about two units in the lower portion of the field. The check plots, X and Y, demonstrate what is a fairly common occurrence: rat damage and low C.C.S. may be co-existent, but actually independent of each other.

In further experiments there were compared samples, each of 25 stalks selected at random from stools of evenly grown crops, and which had suffered similar rat damage over approximately the same time. The following are the C.C.S. results of a typical series of analyses:—

Rat-damaged samples: 11·62, 13·32, 12·87, 13·90, 14·57, and 13·20.
Mean = 13·25 ± ·41.

Sound samples: 14·31, 14·40, 13·43, 14·42, 13·43, and 14·23.
Mean = 14·04 ± ·19.

The standard error of the difference between means—viz., ±0·59—is not significant at the 5 per cent. level.

Figures of this nature are of more interest if further sampling is undertaken in the same rat-infested fields towards the end of the harvesting season, and on some occasions significant differences between sugar contents of the two classes of cane have been found. These differences depend upon the extent and degree of damage due to early attacks and whether attacks have been sustained throughout the season. It appears probable that, in most instances, not more than one unit of C.C.S. is actually lost in harvested cane from fields suffering heavy and continued attack.

3. It is generally agreed that rat attack on sugar cane creates difficulties in harvesting. Stalks, although rat-bitten, may still have normal sugar content at harvesting time and may suffer negligible loss in weight. If bitten some distance from the ground the top portion may have fallen over; if bitten near the ground the stalk may be lodged. Furthermore, stalks may break into pieces when hit at the base with the cane knife or when handled by the cutter; sometimes breaking and/or bending does not occur until the bundles are lifted for loading. Some infestations have a purely nuisance effect, which is thus exhibited at harvesting time, whilst with others economic loss is an additional factor. The relative magnitudes of and the relationship between these two factors will depend to some extent on the variety of cane, the rat species responsible for the attack, the type of attack, the conditions under which harvesting is carried out, and the quality of the crop.

In fields of the short, thick S.J.2 or Badila, or of lodged soft varieties, heavy attack by the pest means that many stalks may be broken up into short

lengths. Normally these, together with dead and dried-out stalks, are left lying in the field. On the other hand, in the field illustrated in Plate 4, although the P.O.J.213 had been heavily attacked (98·5 per cent. rat-bitten stalks), the one or two bites per stalk were near ground level, and the fallen cane could be harvested. Samples taken immediately after burning resulted in mill average C.C.S. values, and probable losses in tonnage were estimated as low. Nevertheless, due to the nuisance factor, this small field was not harvested, and a small intrinsic loss became in effect a comparatively large one. Admittedly this is an abnormal case, but it serves to illustrate the point. Actually infestations resulting in complete loss are rare and usually confined to poorly grown crops where, in all instances, the nuisance factor quickly becomes converted to a true economic loss.

In Queensland a slight increase in the cutting costs of cane attacked by rats is allowed. In recent years, and particularly in the northern areas, when extra farm labour is employed for harvesting, these increases are often the largest monetary loss to the farmer which can be debited to rat attack on cane.

4. There is often little relationship between the percentage of stalks attacked in any field and the degree of damage inflicted, as expressed by the average number of bites per stalk; many contributory factors are concerned, not the least being the thickness of the stalk and the tendency of the damaged stalk to remain upright or in one piece.

Careful observations indicate that the loss of weight in harvested cane is not necessarily the heaviest tonnage loss. The best indication of serious rat damage is usually the amount of damaged cane left in the field after harvesting. The accurate estimation of such cane is often difficult. (In the field depicted in Plate 5, for example, the badly damaged thin variety cane had dried out and some of it was partially or completely burnt during the pre-harvest burn.) In practice two methods of estimating tonnage losses may be used singly or conjointly, depending on the degree of damage. If the damage is extensive the difference between a thorough estimate of probable yield if rat attack had not occurred and weight of cane actually delivered to the mill may be taken as the tonnage loss. If damage is light the amount of cane left in the field should be determined. It has been found that these methods are reasonably reliable; they take into account fairly fully and accurately the several contributory factors concerned, check the inflated losses often calculated by other methods, and also serve to place rat damage in a better perspective. This applies particularly to conditions during normal years when appearance of the damaged cane, plus an almost purely nuisance factor, are often given an inflated economic loss value.

5. Because of rat attack a field may be harvested earlier than would normally be the case and, depending largely upon the variety, this may result in lower C.C.S. returns from that field. Such assessments should, however, be handled with care; for, when the farm is taken as the unit and due consideration is given to what would have been the normal harvesting sequence, equalizing or compensatory factors are often found to have functioned.

Early harvesting as a result of rat attack may result in poor ratoons, and this together with interference with sources of plants and damage to stand-over fields constitute the chief effects of rat attacks on crops for the succeeding year.

6. It has been stated (McDougall, 1940) in discussing the sugar-cane grub pest *Dermolepida albohirtum* Waterh. that "after all the pest is more or less the immediate concern of the individual farmer rather than that of the community as a whole." The same applies to the rat pest. However, in attempting to reduce economic losses caused by these pests it is generally accepted that for some phases of the project collective action is the more expedient, efficient, and practicable. For administrative reasons the collective unit is often a mill area and it is impossible to take the farm as a unit when cost of attempted rat control is debited as a loss due to rat attack.

Under the present communal system of pest control in Queensland cane-fields the cost of rat control does not bear heavily either on the individual farmer or on his district. In certain mill areas the cost of material alone has on occasion amounted to over £2,000 in one year, but this is a peak value, and in most instances a few hundred pounds would cover costs of material in even the worst rat years. Direct administrative costs of applying control measures are low.

Over the past seven years the author has made estimates of tonnage losses caused by rat attacks on sugar cane. In fields scattered throughout a district, losses per farm varying from less than one ton to 50 tons have been assessed, and it has been noted that a large number of infestations did not warrant much attention, so far as tonnage losses were concerned, despite fairly high counts of damaged stalks.

It may be said that, in most districts, no satisfactory statistics on true economic losses from rat damage to cane are available. The reasons for this appear to be:—

(*a*) Sporadic nature of attack;

(*b*) Variation in annual incidence, heavy damage being abnormal;

(*c*) Heavy damage, when it does occur, is seldom general but is usually confined to a comparatively small number of farms in a mill area.

Appreciable tonnage losses are not evenly distributed and have to be borne by a few, and in some districts there is a tendency to convert, by penalty harvesting costs, a nuisance factor into a monetary loss to the farmer. These facts render the problem of lessening losses caused by rat attacks on sugar cane in Queensland more difficult than would otherwise be the case.

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