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A RELATIONSHIP BETWEEN RAINFALL AND RAT DAMAGE TO SUGAR-CANE IN NORTH QUEENSLAND

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SUMMARY

Data on rat-damaged sugar canes, collected over 29 years at a sugar mill, are analysed. The proportion of crop lost each year because of rat damage is shown to be significantly related to rainfall of the drier seasons of the preceding year.

The introduction of pre-harvest burning and poisoning with thallium sulphate in the late 1930s early 1940s resulted in lower levels of rat damage. This is manifested in the present analyses by a lowering of the slope of the regression line relating damage to rainfall.

The regression equation resulting from data from 1942 to 1963 inclusive is used to predict losses for years 1966 to 1977. Except for the first 2 years, estimated losses are close to those observed. Reasons for these discrepancies in 1966 and 1967 are given, as are some suggestions as to how rainfall might influence rat damage.

I. INTRODUCTION

Two species of indigenous rats, *Rattus sordidus sordidus* (Gould) and *Melomys littoralis* (Lönnberg), damage sugar canes in north Queensland cane fields (Gard 1935; McDougall 1944a,b; Redhead 1968). Loss results mainly from degradation of the sugar after the pith of the cane is exposed by rat gnawing. The sugar content of canes so damaged is lowered by 15 to 20% (Bureau of Sugar Experiment Stations 1970) and losses as high as $2 million per year have been estimated recently (Bureau of Sugar Experiment Stations 1975). Control of rats in the cane fields is attempted with thallium sulphate baits applied either from aircraft or from the ground.

Although McDougall (1946a) mentioned years in which *R.s. sordidus* plagued, yearly variation in rat damage has received little attention. Control measures are similar each year, though losses fluctuate. If accurate predictions could be made of the loss each year, control expenses could be tailored accordingly. In addition, knowledge of the relationship between losses and weather conditions should lead to improved control methods.

The only long-term record of losses due to rat damage in Queensland cane fields was given by Farquhar (1967), for the Victoria Mill area near Ingham (18°S, 146°E). That record is used here.

The Victoria Mill area, which contained about 10 000 hectares of cane land in 1963, lies in that part of Australia with the most variable rainfall. The high variability results from heavy rains associated with tropical cyclones, and from periods of unusual dryness due to southerly shifts in the direction of the normally rain-bearing south-east trades (Loewe 1948). McDougall (1946a) considered that weather was the prime factor governing fluctuations of numbers of both *R.s. sordidus* and *M. littoralis.*

Monthly rainfall totals were obtained from the Bureau of Meteorology, Brisbane, for Ingham, the major town in the Victoria Mill area. The mean of values from the three stations was used as the monthly rainfall for the Victoria Mill area. Logarithmic transformation of these monthly means gave a nearly normal distribution (rankit method, Sokal and Rohlf 1969). The monthly distribution of all rainfall, for the period 1941 to 1962, is shown in figure 1.

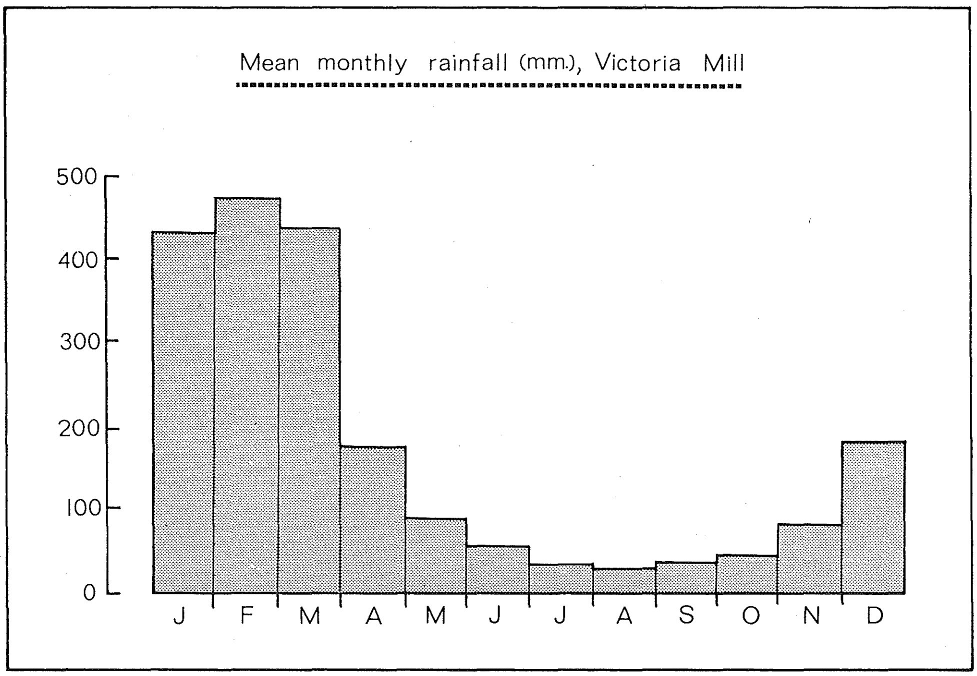


Figure 1. Mean monthly distribution of rainfall, Ingham, 1941–1962.

II. METHOD OF OPERATION

The records given by Farquhar (1967) (table 1) reported 'per cent loss of crop' for each year, obtained from the formula

$$P = F (L) + U$$

where $P =$ % loss of crop

$L =$ % canes found rat-damaged on entry to mill

$F =$ a conversion factor, the value of which was not reported by Farquhar (1967), but which appears to be related in some way to the 15 to 20% loss of sugar in rat-damaged canes, as mentioned above.

$U =$ % of crop left unharvested because of severe rat damage.

TABLE 1

CROP LOST (p) BECAUSE OF RAT-DAMAGE, AND RAINFALL (r) IN APRIL AND MAY OF THE PRECEDING YEAR AT VICTORIA MILL, NORTH QUEENSLAND

Year	1929	1930	1931	1932	1933	1934	1935	1936–1941		1942	1943
r(mm)	197	117	62	237	290	376	222	Thallium poison and burning introduced		495	404
p(%)	2·5	0·6	0·5	1·6	3·5	4·2	3·4			1·0	1·7
Year	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	
r(mm)	152	97	249	81	208	112	193	500	132	112	
p(%)	0·5	0·2	0·1	0·1	0·8	0·6	1·0	1·8	0·1	0·1	
Year	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	
r(mm)	64	536	467	272	178	201	406	114	193	262	
p(%)	0·3	0·7	0·6	1·2	0·3	0·6	1·7	0·6	0·3	0·2	

Estimation of U, the percentage of crop not harvested because of severe rat damage, was done by trained cane inspectors. While the decision not to harvest such portion of the crop would be subjective and variable between farmers and between years, the inspectors' routine estimation of crop yields is a major factor in the management of Queensland's closely controlled sugar industry, and their estimates of such losses are accepted. The percentages (L) of canes which were found to be damaged by rats upon entry to the mill were determined from samples of about 70 canes, each sample being taken from about every 125th cane wagon entering the mill. Approximately 2 000 wagons were sampled each year (Farquhar pers. comm.).

Angular transformation (arcsin) gave a near-normal distribution of Farquhar's per cent loss of crop (rankit method, Sokal and Rohlf, 1969).

In the following analysis, Farquhar's data were split into two blocks; the first for 1928–1934 inclusive, and the second for 1942–1963 inclusive, because baiting with thallium sulphate was introduced to the Victoria Mill area in 1935, and the practice of pre-harvest burning was introduced in 1942. Both procedures have been carried out routinely since their introduction.

Other changes in farm practices occurred during the period 1928–1963. Unlike the introduction of poisoning and pre-harvest burning, they were not aimed directly at the rat problem. For example, the total area of sugar crop harvested each year in the Victoria Mill rose from 5 233 ha in 1928 to 20 573 ha in 1978. This increase was not uniform, there being an expansion of 58% from 1952 to 1955, and another 44% in the period 1964–1966. Secondly, with the advent of mechanical harvesting which chops the canes into billets about 200 mm, it is not possible to compare canes entering the mill in recent years with the whole canes examined by Farquhar. Taking these factors into account, 1963 was chosen as the last year for which data is analysed. It is emphasized that the only use that has been made of post-1963 data was in the testing of the predicted values. In fact, data for the years 1966 (in-field estimates using whole canes) onwards were not obtained from the Victoria Mill Authorities until after analysis of Farquhar's data.

III. ANALYSIS OF THE DATA

For both blocks of data, loss in any year n was correlated strongly with rainfall (R) in April plus May of the previous year (n–1). The regression equations, using data from Ingham were

$$1928\text{-}34 \quad \arcsin \sqrt{P_n} = 4.867 \log_e R - 16.882 \quad (r=0.95)$$

$$1942\text{-}63 \quad \arcsin \sqrt{P_n} = 2.282 \log_e R - 7.744 \quad (r=0.71)$$

Slopes and intercepts of these two lines were significantly different ($P < 0{\cdot}05$ and $P < 0{\cdot}001$ respectively) and both lines intercepted the horizontal axis at the same point. Rainfall data for both blocks were similar (mean of log rain was 5·23 (SE = 0·60) for 1928–34 and 5·32 (SE — 0·63) for 1942–63) and the difference in slopes were not due to differences in the rainfall data. The regression lines are replotted on figure 2.

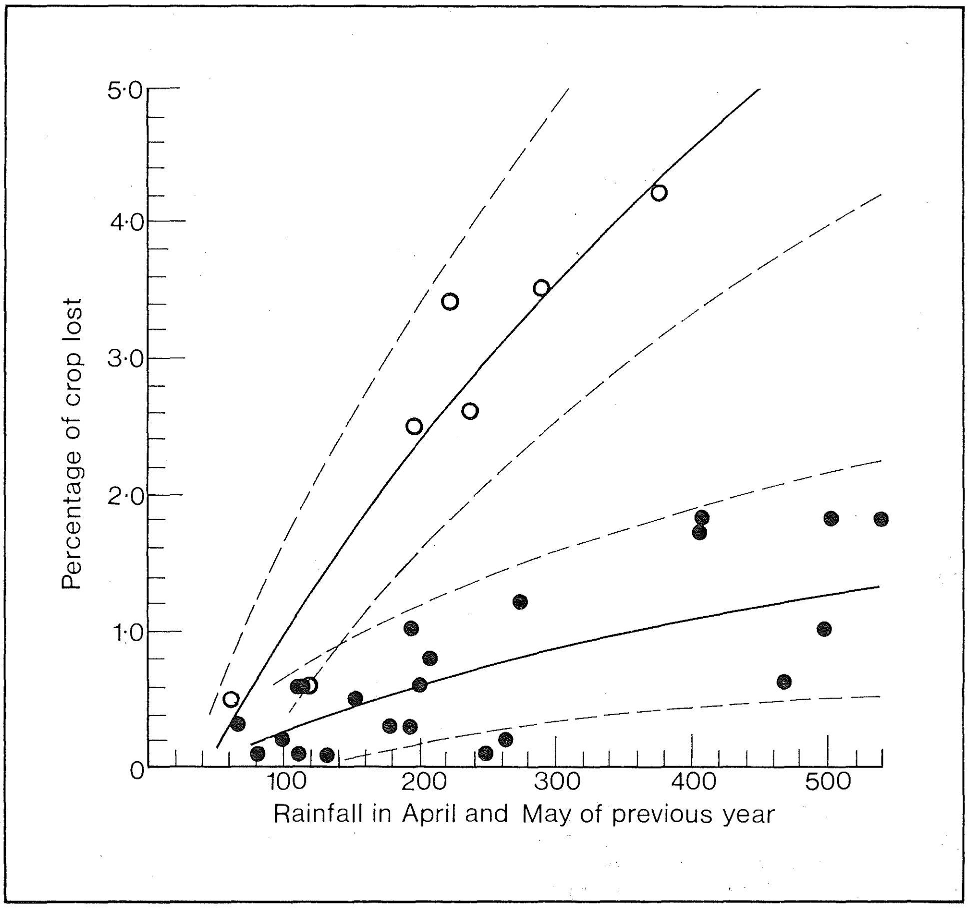
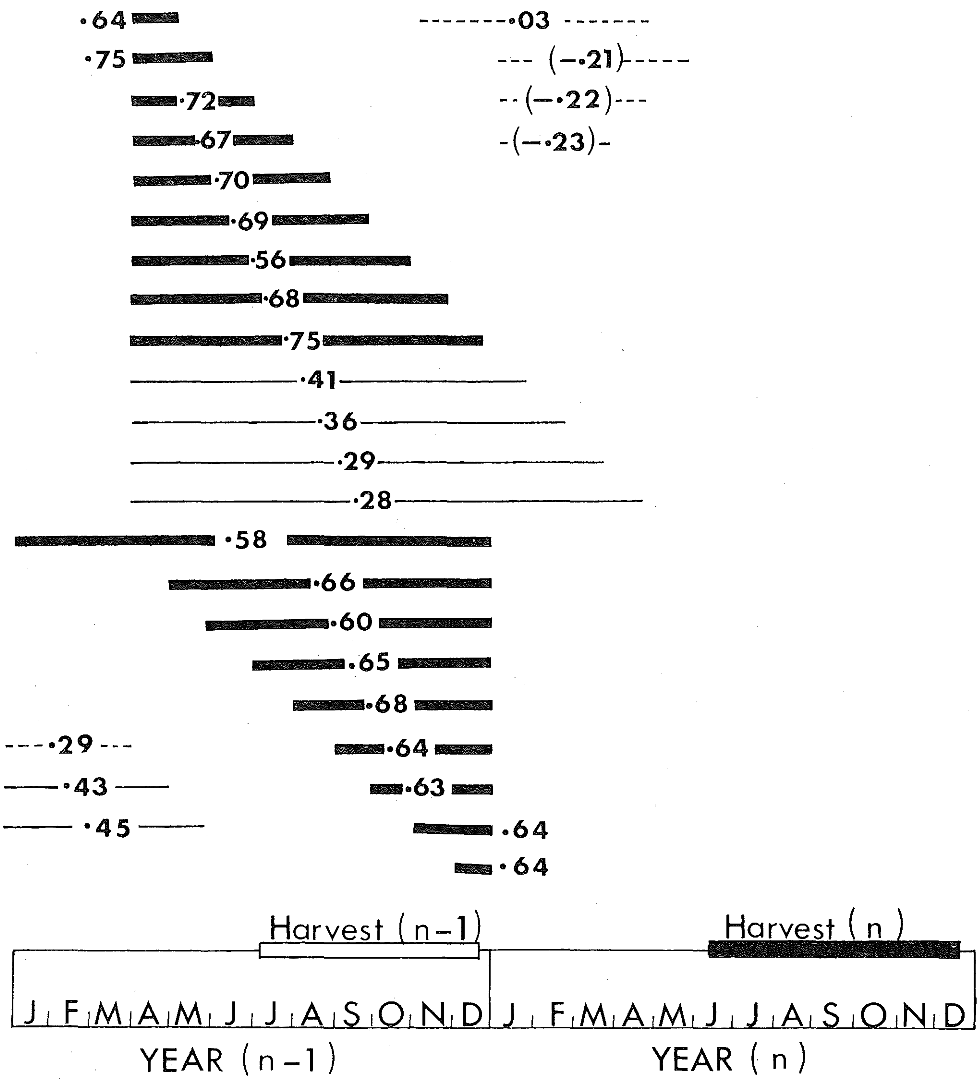


Figure 2. The relationship between rainfall in April plus May of year (n-1) and per cent loss of sugar crop due to rat damage in year n. Eighty per cent prediction limits are also shown.

Using the more extensive data for the 1942–63 period, it was found that rainfall during the period April to December was generally important, in that significant correlations between rainfall and damage in the following year existed for all of those 9 months. Those correlations are summarized in table 2. For this block of data, the best correlation was, in fact, found using rainfall for April + May + November + December (r = 0·79). This was not the case with the more meagre data for 1928–34.

TABLE 2

SUMMARY OF CORRELATION COEFFICIENTS FOR THE RELATIONSHIP BETWEEN RAINFALL IN VARIOUS PERIODS AND PER CENT LOSS OF SUGAR CROP DUE TO RAT DAMAGE IN THE VICTORIA MILL AREA, NORTH QUEENSLAND*



* The horizontal lines represent rainfall periods and the numbers are correlation coefficients between each period's rainfall and loss of crop in year n. Heavy horizontal lines represent rainfall periods for which the correlation was highly significant (P < 0.01), light lines represent rainfall periods for which 0.01 < P < 0.05, and for dashed lines the relationships was not significant.

Multiple regressions with rainfall for April plus May in year (n — 1) as one independent variable, and such variables as rainfall for months in year n, or in year (n — 2) as the other did not reduce the residual variance.

IV. TESTING THE PREDICTION EQUATION

Following completion of the data analysis, further data on per cent loss of crop were obtained from Victoria Mill for the year 1966 onwards. These data were then compared with expected values of per cent crop lost derived from the prediction equation. The observed and expected values are shown in figure 3.

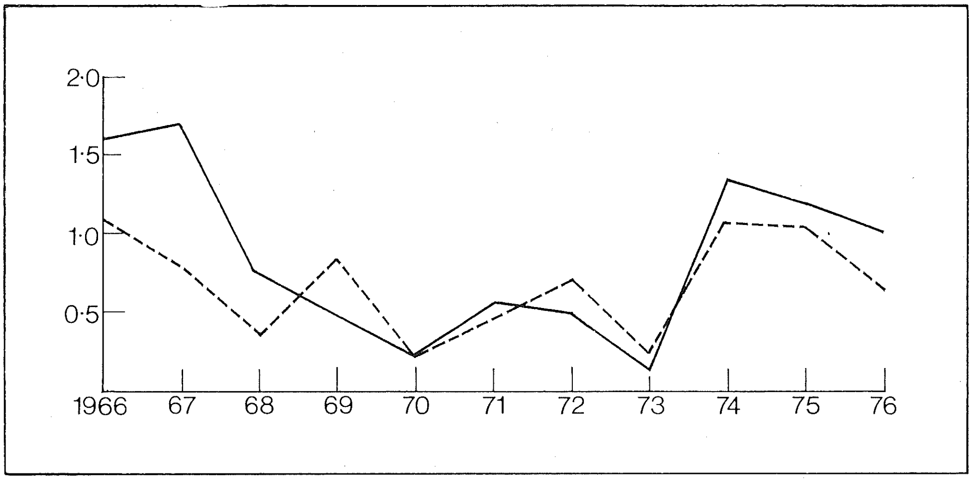


Figure 3. Predicted and observed annual losses of sugar crop at Victoria Mill, north Queensland, 1966–1976.

Except for the 1965 and 1966 crops, the predicted loss was close to that observed each year. As noted above, data after 1963 were not used in the construction of the prediction equation, because there was a major expansion of the Queensland sugar industry at that time. It was considered that the disruption of new and different areas of rat habitat, and the growing of crops in areas where drainage and clearing were not yet completed may have made the response of rats to the presence of sugar-cane fields different from that in the more stable preceding years.

It appears that such a destabilization did occur, with rat damage reaching levels higher than those predicted. However, by 1968 the system was re-stabilized and the predicted and observed levels were in close agreement.

V. DISCUSSION

The close fit of the predicted and observed losses from 1968 onwards is very strong evidence that there is a real relationship between rainfall and rat-damage levels in north Queensland, especially as the test data were not used in the formulation of the prediction model. It is worth persuing, therefore, possible mechanisms whereby such a relationship might operate.

April and May are the 2 months at the end of the wet season in north Queensland. Excessive rain in the earlier months during the wet season (should a cyclone occur, for example), probably exceeds the field capacity of the soil and is rapidly lost by drainage and evaporation. Rain in April or May, however, would have the effect of prolonging optimum conditions for plant growth. Similarly, November and December represent the onset of the wet season. Good rains in these months would also prolong the active growing season.

Although December and November were not included in the regression found to be most useful, it can be seen that the months at the beginning and end of the wet season are of most importance in determining variation in rat damage levels, though rainfall throughout all the drier part of the year, that is, April to December, is also important.

Three mechanisms by which rainfall may regulate damage intensity are suggested. Firstly, although peak reproduction of *R.s. sordidus* occurs after heavy spring (September to November) rains (McDougall 1946b) there is some reproduction during the drier autumn and winter. Good rains during that period may result in increased reproduction leading to higher rat numbers in the following year. Secondly, and perhaps in conjunction with the increased reproduction, autumn and winter rains result in advanced young cane being present before completion of harvesting of the old crop.

By moving just short distances from a harvested field into such advanced young cane, the rats no longer face the necessity of leaving the cane fields and surviving in nearby already occupied grassy areas. Not only would survival be increased by continued residency within cane fields, but the advanced cane would be damaged earlier than in years when growth had been slowed by poorer rain. As Newsome (1969) suggested for the plagues of mice (*Mus musculus*) described by Pearson (1963), the ability to live for 2 consecutive years in fields gave the mice a running start at the onset of favourable conditions. Such a running start can be envisaged for *R.s. sordidus* and *M. littoralis* when good rains in April–December allow them to inhabit cane fields for 2 consecutive years.

By examining the distribution of rat damage in 60 cane fields in 1 year, Redhead and Saunders (1980) found that the level of damage was related to the vegetation type adjacent to each field, with fields adjacent to overgrown, grassed wasteland suffering the most severe damage. Wetter than average winters may result in drains and headlands, which would otherwise be kept mown or burnt, being overgrown. This would result in a larger proportion of the fields in a mill area being associated with nearby grassy areas.

It is likely that all three suggested mechanisms play some part in increasing rat damage following heavier than normal winter rains, and further studies are warranted to investigate them further. In the meantime, rainfall for April and May can be used to predict rat damage in the following years, allowing growers to save money when damage is likely to be low, and to increase control efforts when severe damage is predicted.

VI. ACKNOWLEDGEMENTS

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