BSES

RODENT MANAGEMENT IN SUGARCANE

A co-operative study involving:

Bureau of Sugar Experiment Stations

Queensland University of Technology

Sugar Research Council

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PREFACE

This meeting was designed to provide information on rodent management research and development of a prototype integrated strategy for ground rat control to the grower and miller representatives on Cane Pest and Disease Control Boards, Canegrower District Executive members, Mill Supplier Committee Members, Pest Board and Productivity Committee staff and BSES personnel.

The information to be presented consists of three parts:

(a) Results from the research program on canefield rat control conducted at Ingham from 1985-89;

(b) Details of a proposed coordinated rodent management strategy for the Ingham district; and

(c) A discussion on how various groups might cooperate in developing and implementing a similar control strategy for other mill areas.

The rodent control strategies which will be outlined at the meeting represent the most significant attempt at improving the management of these pests over the past 30 years.

As such I commend it to you and urge your future participation, but emphasise that before the strategy can be successful each participating Pest Board must consider allocating priority to the project and commit resources to its implementation. If these steps are taken then the program will be successful.

Colin C Ryan
<u>Director</u>

AGENDA

Morning session

Chairman:	E S Wallis, Group Manager, BSES
1000	Welcome - E S Wallis
1010	Overview - K J Chandler, BSES
1030	The Management of Rodents in Sugarcane - J Wilson and D Whisson, QUT
1130	Discussion
1230	Lunch

Afternoon session

Ingham

Chairman: L G W Tilley, Senior Extension Officer, BSES

Mackay

Chairman:	W A C Webb, Extension Officer, BSES
1330	Welcome
1340	Overview - K J Chandler, BSES
1400	The Management of Rodents in Sugarcane - J Wilson, QUT
1500	Discussion
1600	Close

RODENT CONTROL IN SUGARCANE: A NEW PERSPECTIVE

by

K J Chandler, Research Officer, Meringa Sugar
Experiment Station

BACKGROUND INFORMATION

The Queensland sugar industry has had a long association with the native rodent population resident in canefields. Cane Pest and Disease Control Boards, since their inception have recorded the presence of canefield rats and the need for their control. In former times, Wiel's disease which is spread by rodents was the major concern of all canefield workers. Sugarcane yield loss through rat damage has always been regarded as significant although the extent of these losses has not always been quantified accurately.

Numerous toxicants and various application methods were assessed by pest boards, CSR technical staff (Wilson and Gard) and BSES (McDougall, Wilson, Redhead, and Hitchcock) as being the **prime** solution to the ongoing rat infestation problem in sugarcane.

McDougall, and to a lesser extent, Gard and Redhead attempted to understand factors influencing the distribution, size and frequency of canefield rat plagues. However, these workers did not attempt to develop theories of a rational control strategy which incorporated this information.

Throughout the 1960s, 1970s and early 1980s, baiting campaigns with rodenticide continued to be the only control strategy used in response to rat damage in sugarcane.

The need for a more rational, cost-effective and environmentally acceptable approach to canefield rodent control is apparent. The cost of developing and employing alternative strategies can easily be justified in terms of the historical record of crop losses and baiting costs.

During 1984, BSES funded a project involving researchers from the Queensland Institute of Technology (now QUT) to develop a prototype integrated strategy for ground rat control in the Herbert River district, one of the areas most consistently and severely affected by rat infestation.

The basic research has been completed after a five year cooperative effort involving significant and valuable contributions by staff of both BSES and Pest Boards. A prototype management strategy has been prepared and tested over the last four years, proving to be economically justifiable.

It is important to note that the study at Ingham was a pioneering effort, and that further information is still being acquired to improve the rat management strategy in that district.

This Ingham study deals specifically with the canefield rat. Inferences cannot be drawn concerning climbing rat and its damage pattern. A strategy for climbing rat will require a separate study, the logistics and economics of which may need to be the subject of a feasibility study.

Development of a similar research program for the Mackay district was commenced with funding provided by the Sugar Research Council and extensive cooperation from local Pest Board officers during 1988.

Annual coordination of effort between growers, Cane Pest and Disease Control Board staff and BSES staff will be necessary for the successful operation of an integrated rat control strategy.

The coordinated approach to rodent control which will be outlined has much to commend it, and warrants careful consideration. For further information on the application of this control strategy, please contact Keith Chandler on (070) 56 1255, or your local BSES extension officer.

THE MANAGEMENT OF RODENTS IN SUGARCANE

J. Wilson & D. Whisson
Centre for Biological Population Management
Queensland University of Technology

THE SITUATION

Rodent damage to sugarcane has been of concern to the Australian sugar industry since the 1930's. In more recent times, annual surveys have indicated that damage by rodents occurs over approximately 50% (150,000 ha) of sugar producing areas resulting in annual losses of between two and four million dollars. A further $0.6m is expended on annual baiting programs.

Rodents are therefore the second most serious pest of the sugar industry.

On a regional basis, losses and associated control costs can be assessed from annual surveys of rodent damage conducted by Cane Pest and Disease Control Boards.

The Mackay Cane Pest and Disease Control Board have estimated losses due to rodents since 1984 (Table I).

These estimates demonstrate the economic impact of rodents at the regional level but do not necessarily represent the extreme case. Northern regions regularly record stalk damage rates significantly higher than those occurring in the Mackay district.

Economic impact results from both a decrease in the yield of cane and a loss of sugar content. Although only one or two internodes of a stalk may be directly damaged by rodents, the sugar content can be reduced by 15% to 20% as a result of secondary damage by bacteria and fungi.

Cost-effectiveness is the ultimate test of any control strategy as control practices represent a cost to the industry that must be balanced by a benefit to production.

Factors influencing the cost-effectiveness of rodent control programs in sugarcane crops include:

- The severity of overall damage in a region;
- The effectiveness of the control program;
- The cost of the control program;
- The current market value of sugar.

The influence of some of these factors on the likely cost-effectiveness of current rodent baiting campaigns at Mackay are illustrated in Table II.

To be cost-effective, any control strategy must be able to provide answers to three questions:

- In any year, what will be the overall level of damage within a district;
- How will damage be distributed throughout a district;
- What are the most effective methods to tackle the specific problems of a particular year?

The answers to these questions must be known well in advance of the occurrence of the problem. The high reproductive capacity of rodents dictate that it is more efficient to prevent the problem from occurring, than to commence control measures after the problem has arisen and damage has started to occur. Rodent control programs which rely solely on baiting are inefficient methods of reducing crop damage.

A reliable estimate of potential crop damage is essential if rational decisions are to be made regarding the extent of a control program.

A system designed to provide early warning of potential

Table I

Summary of rodent baiting campaign costs and rodent-induced crop losses at Mackay, 1984-1986

Year	Aerial baiting details		Calculated crop losses (*1*)	
	Hectares baited	Cost ($A,000)	Tonnes sugar	Net value ($A,000)
1984	22700	66	12900	1834
1985	37360	108	2600	308
1986	37140	130	4114	740

1 Values calculated in $A, using relevant market price for sugar less official estimated harvest costs and charges

Table II

Estimated costs and monetary returns of a rodent-baiting campaign in sugarcane, using actual data from Mackay, 1984-1986

Year	% damaged stalks	Net return $A/tonne sugar (*1*)	Baiting costs (2) ($A,000)	Estimated benefit ($A,000) from damage reduction of 10%	20%	30%	40%
1984	16.0	142.2	190	204	459	786	1223
1985	3.4	118.5	190	34	77	132	205
1986	4.6	179.9	234	82	185	317	493

1 Values calculated in $A, using relevant market price for sugar less official estimated harvest costs and charges

2 Calculated cost of baiting the total Mackay crop of 65000ha, based pro-rata on actual costs shown in Table I

crop damage must therefore form an integral part of any control strategy.

If the timing, location and intensity of rodent outbreaks can be predicted with adequate accuracy well in advance of the occurrence of damage, the most cost-effective prevention methods can be implemented.

THE SPECIES

Two rodent species are responsible for damage to cane:

- *Rattus sordidus*, the canefield rat;
- *Melomys burtoni*, the climbing rat.

Some industry sources have assumed that damage caused by the climbing rat is of greater industry significance than that caused by the canefield rat. In part, this view has arisen because damage due to the climbing rat is more visible to the casual observer.

Extensive trapping has shown conclusively that the canefield rat is the major cause of damage (greater than 90%) in areas south from the Herbert River district. Preliminary trapping has indicated that the canefield rat is also responsible for a large proportion of the damage inflicted in the flat, extensive, canegrowing areas north of the Herbert River district.

The climbing rat is the major offender in the highly dissected, narrow valleys of the more northerly areas where many canefields are adjacent to forested areas or vegetated creek banks.

Approximately 75% of land assigned to canegrowing is in areas where the canefield rat is responsible for over 90% of total rodent damage. Therefore, damage caused by this species is of far greater economic significance to the sugar industry.

R. sordidus is a grassland animal, favouring areas of friable soil with a close ground cover of grasses, sedges and herbs. Favoured habitats include grasslands, grassy fringes of forests, open forest bordering closed forest and the edges of swamps and watercourses.

It is not surprising that plantations of cane are favoured habitats as they closely resemble the preferred native habitat. Canefields provide good ground-cover and friable soil able to support the extensive burrow network constructed by this colonial species.

In its native habitat, the diet of the canefield rat consists mainly of grasses together with small amounts of seed and insects.

This animal has one of the highest reproductive potentials of any native rodent. The oestrus cycle is six days long and the gestation period is about 22 days. Average litter size is six and the young are independent at 18 days of age. Females are capable of having their first litter when they are approximately 65 days old. Theoretically, the canefield rat is capable of producing up to one hundred and twenty young in six months.

CURRENT CONTROL SITUATION

This relies entirely on the widespread aerial application of packeted thallium-treated wheat baits. Trials in the Ingham and Babinda areas have shown that although this procedure can reduce the incidence of rat-bitten stalks significantly, results are extremely variable and success depends on:

- the severity of the rodent infestation;
- the timing of the control procedure.

Major limitations of the current procedure include:

- Aerial distribution is non-selective and therefore costly, with baits being applied at the same rate regardless of the level of infestation. Generally, rodent damage within a district is patchy;
- Thallium treated wheat is unpalatable to the

canefield rat during the breeding season and therefore baiting must be delayed until increasing 'bait takes' occur towards the end of the breeding season. At this stage, population levels are high and damage has started to occur;

- Thallium sulphate is toxic and in packeted bait form is accessible to a wide range of non-target species.

The timing of baiting programs is critical to their success. A simulation of a rodent population with similar life-history characteristics to the canefield rat (Figure 1) shows that without control, the population increases as a result of breeding.

During the increase phase, a population level is reached where damage becomes apparent in the field. In the absence of control, the population then starts to decline as breeding has ceased but mortality continues.

If a successful baiting program (80% mortality) is implemented when the population is at its peak, the control program achieves little over what was about to happen in the normal course of events.

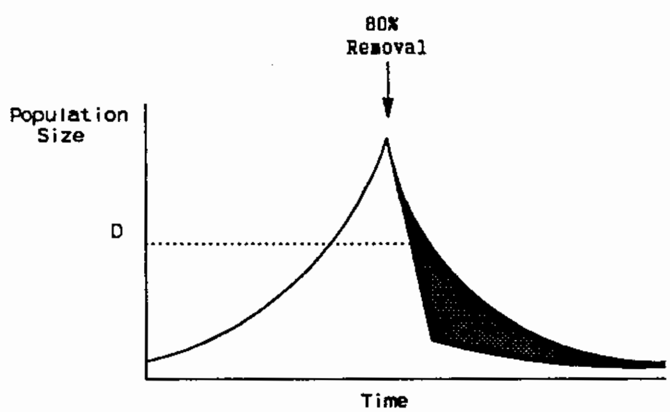

Figure 1

Simulated growth of a rodent population
with removal at peak density

Solid area represents the change in population trajectory with 80% of the population removed at peak density. D represents the population level at which significant damage is first observed

In this situation it is possible to believe that the control procedure has been successful and that the expenditure has been justified when actually, no significant change in population trajectory has occurred.

Despite baiting programs at Mackay during 1984-1986, significant rodent damage still occurred (Table II).

AN ALTERNATIVE APPROACH TO CONTROL

An alternative approach involves predicting population levels in advance of crop damage and implementing cost-effective responses when and where necessary. These responses include:

- Reducing the extent of breeding;
- Reducing the potential for crop colonisation and establishment;
- If necessary, applying additional control in the form of bait treatment.

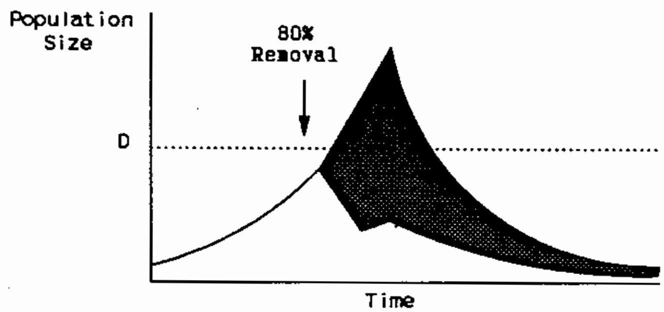

Figure 2

Simulated growth of a rodent population
with removal prior to peak density

Solid area represents the change in population trajectory with 80% of the population removed before significant damage is observed. D represents the population level at which significant damage is observed

Regular monitoring of population levels allows the potential for damage to be assessed well in advance of the problem occurring. In turn, this allows a response to be initiated before the population attains peak density. In this case, the population will still reach a peak after the control program is implemented since surviving animals will still breed. However, population levels will be significantly reduced.

If the success of breeding and the potential for crop colonisation can be reduced by modifying the habitat to remove factors that are necessary for high breeding success and, (b) reduce the size of harbourage populations that form the basis of future colonising populations, then the population will be suppressed and crop damage will be significantly reduced. The cost of these alternative control procedures will be lower since the areas supporting populations that require additional control will also be reduced.

If these methods result in the population being reduced by the same amount as in the previous simulation (80%), but two to three months earlier (Figure 2), the population will be reduced during the early stages of the breeding season. In this case, significant reproduction will be delayed, the population does not reach a critical size and crop damage will not reach significant proportions.

This alternative approach is an integrated control strategy combining both biological and chemical methods in an orderly sequence, based on an understanding of the population cycle of the target species.

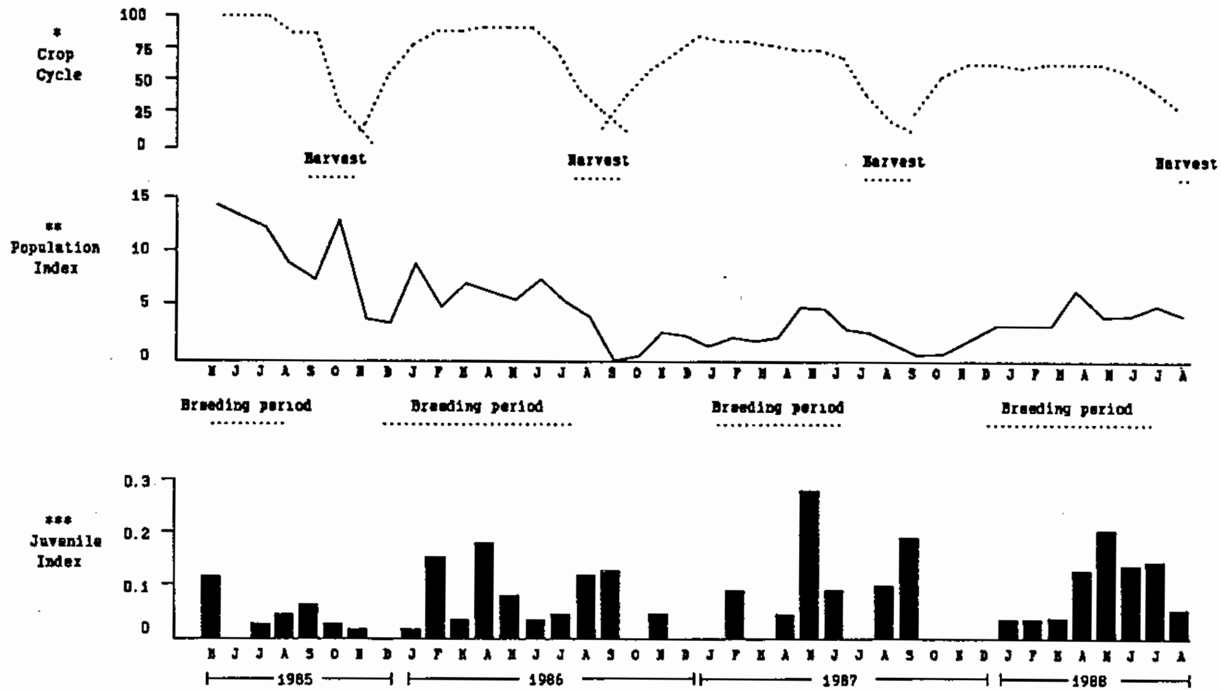

Figure 3

Population cycle of the canefield rat in the Herbert River district

* *% crops greater than two months old*
** *captures per 100 traps*
*** *proportion of juveniles*

THE POPULATION CYCLE

The population density of *R. sordidus* in the Herbert River district (Figure 3) cycles annually with the amplitude of the cycles being dependent on environmental conditions that dictate breeding success and mortality.

The population cycle is closely related to the crop cycle. Conventional crops are not invaded until they are two months old when they provide the minimum level of cover necessary for colonisation (Figure 4). At this stage, crops are colonised by mature, non-breeding individuals from surrounding harbourage, colonies are established and the mature population remains stable until breeding commences.

A well defined breeding season occurs each year and commences between November and March. The onset of breeding is associated with the first appearance of summer grasses in and around the crops (Figure 5). Breeding intensity peaks one to two months after the first pregnancies occur and declines rapidly thereafter. Breeding ceases around July regardless of climatic conditions.

Juveniles enter the population at the peak of the breeding season and peak population size occurs one to two months later. In general, population size decreases over the June/July period due to the death of older individuals and continues to decrease as younger individuals disperse as a result of the breakdown of breeding colonies.

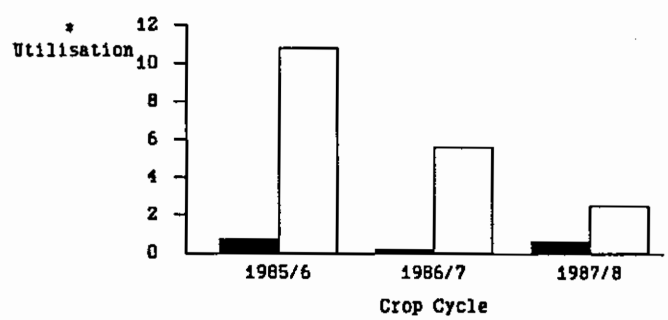

Figure 4

Utilisation of crops

solid block: crops less than two months old

open block: crops greater than two months old

* *percentage trap success*

The beginning of the harvest season coincides with the start of dispersal, resulting in a large redistribution of animals between crops and refuge areas. During this period many crops inherit rodent problems from neighbouring areas. Animals which survive this redistribution over the July - December period provide the nucleus of populations that will invade crops the following season.

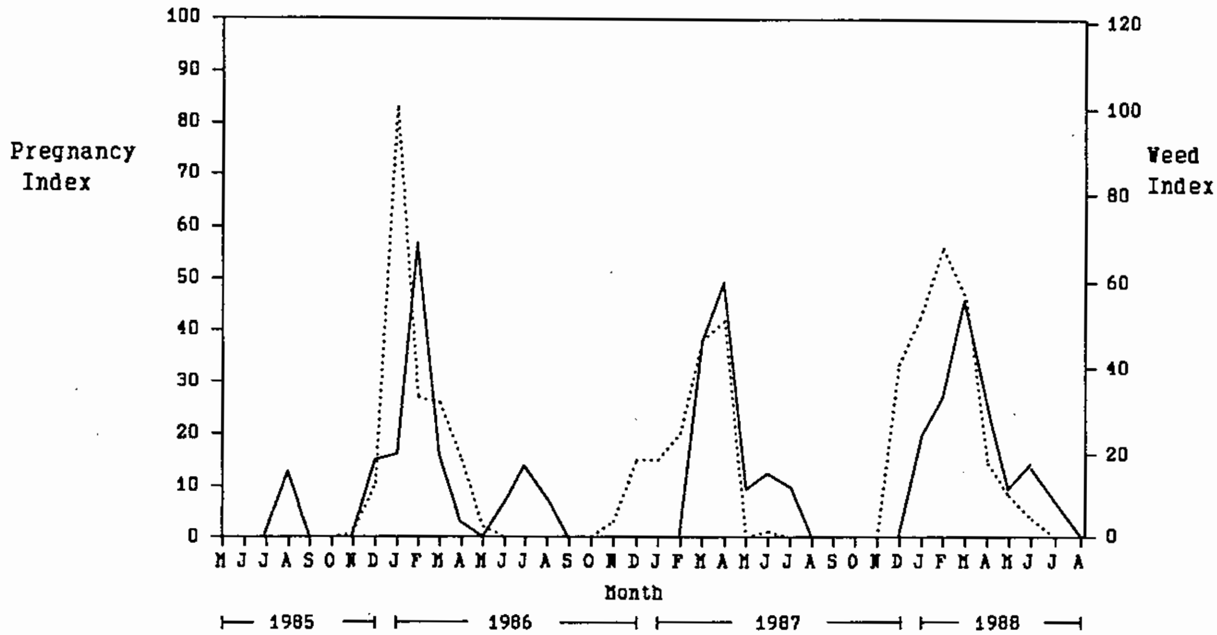

Figure 5

Relationship between pregnancies and in-crop weeds

—— *% mature female stratum pregnant*

------ *biomass of summer grasses (g m-2)*

Significant crop damage does not occur until after the peak of the breeding season (Figure 6). This damage pattern is also reflected in stomach contents. The diet of *R. sordidus* changes dramatically between the breeding and non-breeding season (Figure 7). Over the breeding season, diet consists almost entirely of non-cane vegetation and seeds. Once the breeding season has finished, there is a dramatic switch to cane. As seed and vegetation form the major part of the diet over the breeding period, it is likely that weeds are necessary to provide the high nutritional requirements of females for breeding and of males for colony maintenance and defence. Studies have shown that *R. sordidus* cannot exist and breed when fed solely on sugarcane.

The overall success of the population in any given year is dependent on the time of onset of reproduction. If conditions favourable for reproduction occur early (November, December), then populations have the potential to increase rapidly and attain high densities before breeding ceases.

During the 1984/85 season, conditions in the Herbert River district were favourable for early breeding and Victoria Pest Board data suggest that breeding occurred in November resulting in heavy crop damage.

Breeding commenced in December in the 1985/86 crop and the potential for crop damage was high. However a cyclone caused extensive flooding and reduced population density to such an extent that only moderate crop damage was recorded.

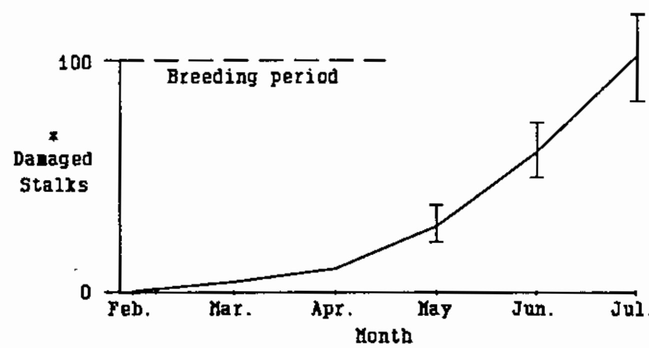

Figure 6

Pattern of damage to cane

* *cumulative % of total damage*

The 1986/87 season was extremely dry with no significant rain until February 1987. Breeding did not commence until March and damage was low.

In 1987/88, conditions were favourable and breeding commenced in January but the residual population from the previous year was small in size and was in poor condition following an unfavourable year. Under these conditions, the population could not realise its full potential before breeding ceased around July.

Conditions were extremely favourable in the 1988/89 season; the size of the seeding population from the previous year was relatively high, early rains ensured a

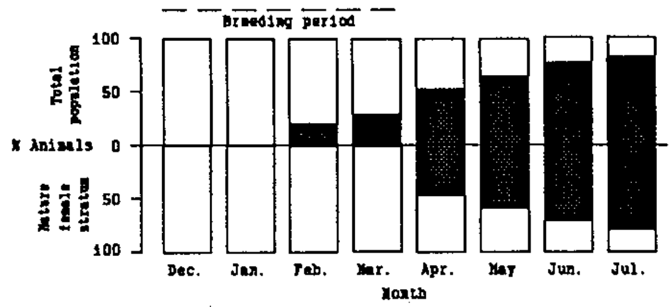

Figure 7

Diet of the canefield rat

open block: *% animals with stomachs containing over 50% seed and vegetation*

solid block: *% animals with stomachs containing over 50% sugarcane*

good supply of summer grasses and breeding commenced in December. The potential for damage was extremely high and the population was increasing rapidly until a cyclone caused extensive flooding and significant crop damage was averted.

Continued monitoring over a number of years will provide the data required to verify this trend but it is obvious that a one to two month extension of the breeding season can greatly affect the potential for crop damage.

Despite the effects of environmental factors on population density, population fluctuations in each year follow a predictable cycle (Figure 8).

THE SIGNIFICANCE OF NON-CROP AREAS

As *R. sordidus* is a grassland animal it is not surprising that grasslands support a significantly higher population density than any other non-crop area (Figure 9).

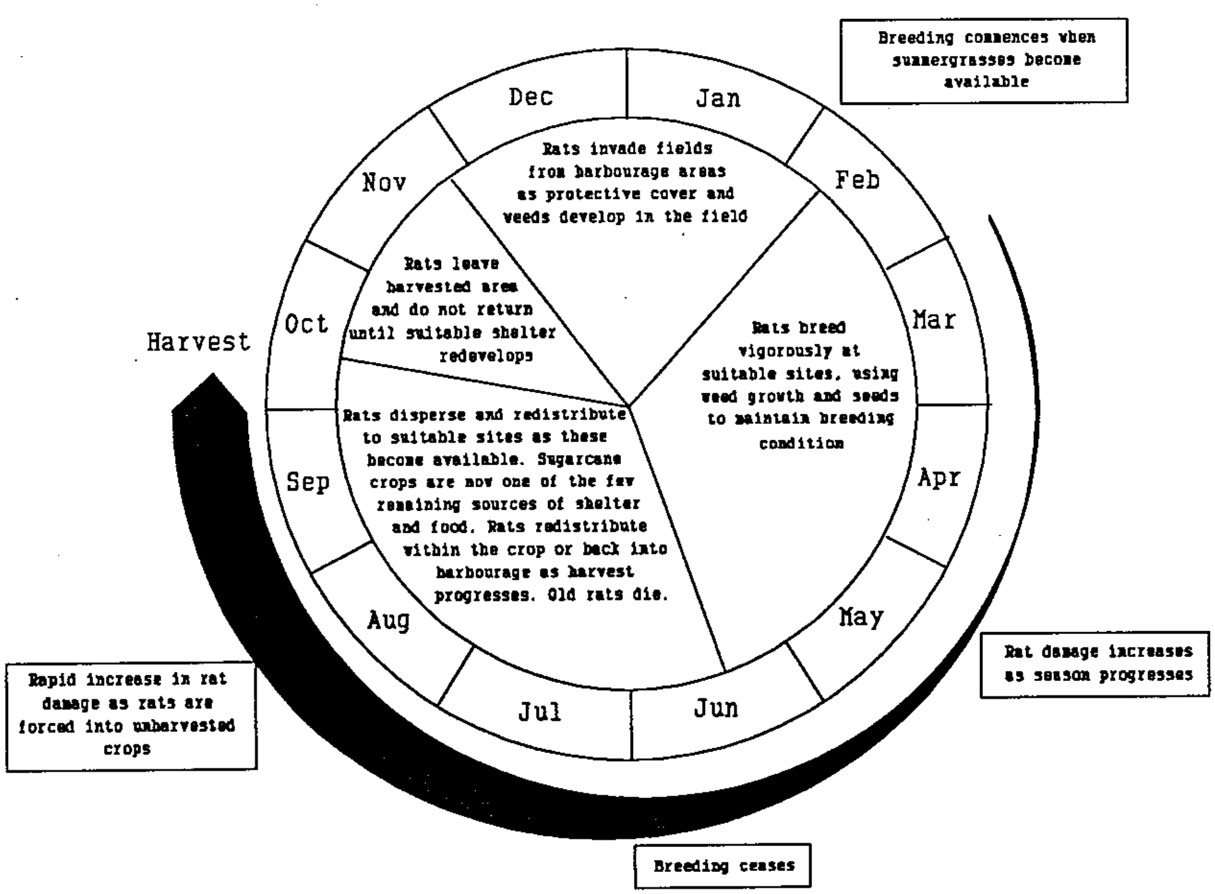

Figure 8

Annual population cycle of the canefield rat

Woodlands and the grassy fringes of drainage channels also support substantial populations whereas the low light penetration and sparse ground cover associated with closed forests result in a low level of utilisation. Grazing paddocks are also poorly utilised as low grass height, regular disturbance by cattle and soil compaction make colonisation and establishment difficult.

Attributes such as vegetation cover, plant species composition and the physical structure of non-crop areas determine the level of utilisation. In addition to grasslands, the blady grass of woodlands and para grass surrounding drainage channels and swamp margins provide the cover required for establishment whilst the wide variety of herbs and grasses in these areas provide a nutritious food source. These characteristics result in heavy utilisation by rodents.

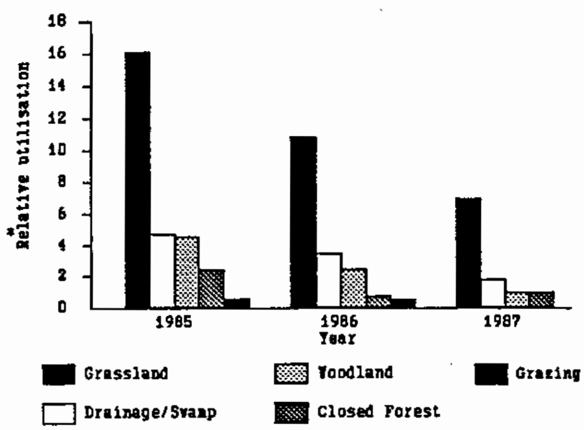

Figure 9

Utilisation of non-crop habitats

* *percentage trap success*

THE SIGNIFICANCE OF AGRICULTURAL PRACTICES

The relationship between the onset of breeding and the first appearance of summer grasses, coupled with the dietary switch between the breeding and non-breeding season indicates that breeding is dependent on the availability of a non-cane food source. Studies involving weeded and unweeded sections of fields have shown that in-crop weeds play an important role in determining the potential for crop damage.

Weed control can be achieved in two ways:

- Herbicide treatment;
- Trash-blanketing.

The elimination of weeds from a crop through the use of herbicides resulted in significantly lower populations throughout the population cycle compared with the populations in non-weeded areas (Figure 10). At the end of the breeding season, population density in the unweeded areas increased rapidly as juveniles entered the population. A similar increase did not occur in the weeded areas where juvenile recruitment was less than

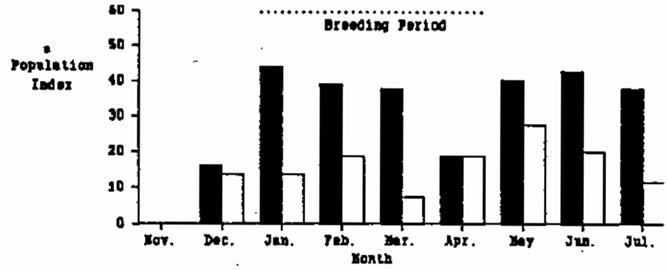

Figure 10

Utilisation of weeded and unweeded conventional crops

solid block: *unweeded crops*

open block: *weeded crops*

* *percentage trap success*

50% of that in the unweeded areas.

The suppression of the population due to the removal of weeds resulted in a 60% reduction in damage to the harvested crop (Figure 11). Stomach content analyses of rodents trapped in weeded areas show that seed and non-cane vegetation still predominated in all breeding females, indicating that they are forced to forage over a much larger area than their counterparts in unweeded crops.

The cover provided by heavy trash-blanketing and minimum tillage techniques allows *R. sordidus* to colonise these crops earlier than conventional crops, however the suppression mechanism due to the absence of weeds still operates, and rodent populations establish at lower densities (Figure 12) as a result of reduced breeding success.

The practice of green cane harvesting and heavy trash-blanketing should result in a general reduction of damage throughout a district, however these crops are particularly susceptible to early invasion by juveniles from adjacent weedy, conventional crops as the trash provides more cover for dispersing animals. The amount of damage at harvest will depend on the proximity to weedy, conventional crops and favourable non-crop areas. In extensive trash-blanketed areas, damage reduction will be similar to that obtained with herbicide treatment. In areas where there is a mosaic of both crop types, damage to trash-blanketed crops could be as high as in conventionally treated neighbouring crops as a result of rodent dispersal.

DAMAGE POTENTIAL

Rodent damage within a region is patchy as not all locations have a similar potential for damage. The ability to direct control effort to locations where it is most needed is essential if the cost-effectiveness of the control process is to be maximized.

For a particular location to sustain significant damage, several processes must occur:

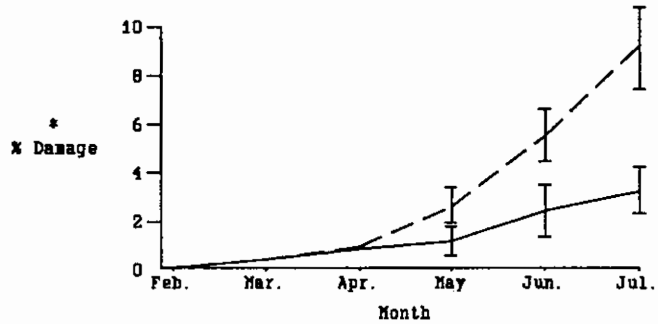

Figure 11

The effect of weeding on damage

— *weeded areas*

------ *unweeded areas*

* *cumulative percentage of damaged stalks*

- Invasion;
- Colonisation and establishment;
- Breeding and survival.

Conventional crops less than two months old are free of rodents and so invasion must occur on an annual basis. Invasion occurs from stable refuges (non-crop areas) that are not subject to the major disturbances of cultivation and harvest. The quality and size of refuges determines the size of the refuge rodent population and hence the potential for crop invasion. Refuge quality can be ranked on the basis of rodent utilisation (Figure 9). Grasslands

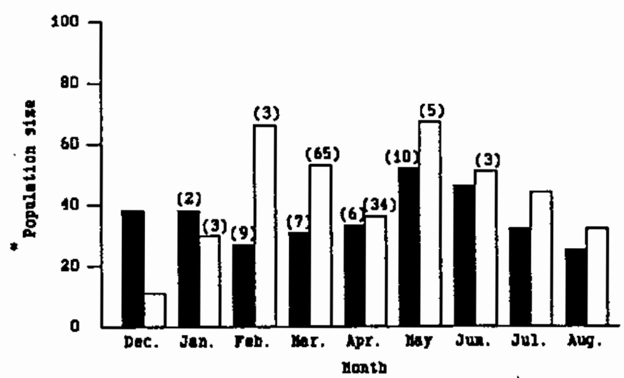

Figure 12

Utilisation of conventional and trash-blanketed crops

solid block: *trash-blanketed crops*

open block: *conventional crops*

( ) *% mature female stratum pregnant*

* *% trap success*

support higher densities of rodents than open forests which in turn are more utilised than other refuges.

The proximity of high quality refuges alone, is not sufficient to explain the extent of crop invasion. The ease of rodent movement between refuges and crops must be considered. Factors such as the distances to the nearest significant refuges and the type and extent of corridors (for example, drainage channels) connecting the refuges to the crop also affect the potential for invasion.

The potential for colonisation and establishment depends on available shelter, food and the ability to construct burrow networks. Weeds, crop type and soil characteristics are important in this process.

The main factor affecting breeding and survival is the presence of weeds to provide the nutritional requirements for breeding. The effect of weeds and crop type on breeding and juvenile recruitment has been discussed previously.

R. sordidus is a colonial animal that constructs elaborate networks of burrows and runways. Soil characteristics are important in this process. Breeding occurs over the wet season and soils that waterlog readily or cannot support burrows over this period because of structural characteristics will affect the potential for breeding and survival.

The effect of these factors on the potential for crop damage was determined in a study involving more than 360 sites within the Herbert River district.

Crop damage was assessed at each site and each site was classified as follows:

- Crop type (conventional/trash-blanket);
- Degree of lodging;
- Percent weed cover;
- Weed distribution (uniform/patchy);
- Dominant weed species;
- Soil characteristics (binding, drainage, ease of digging, surface type);
- Proximity of refuges (distance from site, type, extent, number, size, type and extent of connecting corridors).

Figure 13 shows those characteristics and interactions which are necessary to explain the observed pattern of crop damage. It is important to realise that these characteristics do not operate independently. Damage potential is determined not only by the contribution of individual characteristics, but also by the associations between characteristics.

The strongest association is between weed cover and damage. Sites with high weed cover were consistently associated with more damage than sites with low weed cover, regardless of soil and refuge type.

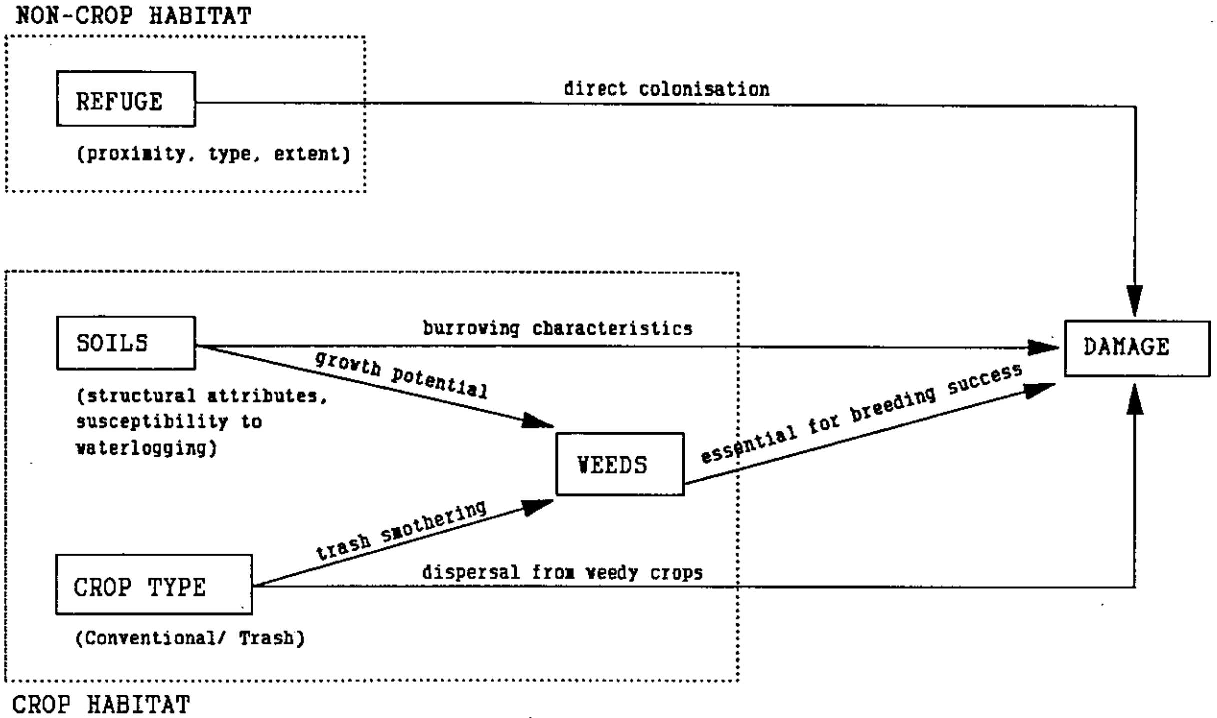

Figure 13

The influence of site attributes on rodent damage

The proximity of refuges is the next most important characteristic and acts in association with weed cover. If in-crop weeds are low, the presence of grassland and open forest refuges results in an increase in crop damage. If in-crop weeds are high, the importance of these refuges is diminished, the major contribution to crop damage coming from weeds. Sites associated with other refuges sustain low damage if in-crop weeds are low. Damage will be extremely low if these sites are associated with the poorer soil types.

If all other site characteristics are equal, damage will be higher in those crops on good soil types.

Highest damage can be expected at a site that possesses the following characteristics:

- Conventional tillage techniques;
- High in-crop weed cover;
- Well drained, friable soil;
- Close to substantial grassland or open forest refuges;
- Area highly dissected with creeks or drainage channels;

Conversely, lowest damage is associated with:

- Conventional or heavy trash-blanket techniques;
- Low weed cover (herbicide treatment);
- Isolation from refuges;
- A site surrounded by crops with similar characteristics.

These relationships, together with supporting information from aerial photography, soil maps, hydrological maps and information on the distribution of tillage techniques will allow districts to be divided into general areas of low, moderate and high damage potential. In turn, this will allow additional control to be directed to areas where it is most needed.

At present, the division of the Herbert River district into areas of low, moderate and high rodent damage potential is based on general conditions that explain the observed damage pattern due to *R. sordidus*. It is still possible that some growers in low damage potential areas will have high damage potential in specific fields, but this will be the exception rather than the rule. As the model is refined, it will be possible to re-draw the boundaries with greater precision and provide a damage potential index for smaller areas.

THE NEED FOR AN EFFECTIVE BAIT

Changes in agricultural practice, more attention to crop cleanliness and the modification of non-crop areas to make them less suitable as refuges will have a beneficial effect on crop damage. There will however, always be a need for an effective bait to cope with emergency situations or to be used in situations where changes in cultural practices are impractical. An effective bait must be toxic and palatable to the animal at a time when the population is most susceptible to control. The timing of bait application is critical and for an animal with the reproductive capacity of the canefield rat it is essential that the population be reduced early in the breeding period.

Data on 'bait takes' from various Cane Pest and Disease Control Boards suggest that thallium baits are unpalatable until after the peak of the breeding season. The poor general palatability of thallium baits was confirmed in a laboratory study (Table III) where baits were presented to *R. sordidus* (a) as the sole food source and (b) in the presence of standard laboratory food over a 48 hours.

Mortality decreased to a non-effective level in the presence of an alternative food source as a result of poor bait acceptance. The effectiveness of the bait was not increased by prolonged exposure of up to 28 days.

Table III

Mortality of *R. sordidus*
due to packeted thallium baits

	Alternative food source			
Stratum	Absent		Present	
	No. animals	No. deaths	No. animals	No. deaths
male	23	18	21	2
female	20	18	21	1
Total	43	36	42	3
% mort-ality	84		7	

A bait-base has been developed that is palatable over the breeding season. Field consumption of the bait-base was measured at sites supporting rodent populations of different size and breeding intensity (Table IV). High consumption rates were achieved regardless of population size or breeding intensity. The bait-base is currently being tested in field trials in the Mackay area to confirm palatability over the breeding season and to determine consumption rates under a variety of field conditions.

The bait-base is inert so that a variety of rodenticides can be incorporated, depending on which material is registered for use in sugarcane.

The addition of attractants to a bait-base will also increase the efficiency of a field bait by increasing the probability of the rodent finding the bait and/or masking an unpalatable flavour imparted by a rodenticide. Laboratory studies have identified three compounds that increase the number of visitations to a bait and the consumption of the bait by *R. sordidus.* These compounds are being assessed in field trials in the Mackay area.

MANAGEMENT IMPLICATIONS

It is clear that long-term, cost-effective control of rodents should rely on an integrated management program which combines both chemical and biological control methods applied in an orderly sequence. The objective of such a control program is to prevent the problem from occurring rather than to apply treatments in a reactive manner in an attempt to control large populations.

A three phase management program is necessary:

- Population monitoring to provide estimates of the overall level of regional damage;
- Management of cropped areas to reduce the extent of colonisation and establishment;
- Strategic baiting of high-risk areas at the correct phase of the population cycle in years when overall damage is expected to be high.

Implementation of such a program is a decision for representatives of the sugar industry since the program relies on procedures at three levels. There are separate and distinct roles for growers, Pest Boards and BSES.

In deciding on the method of implementation, the following should be given consideration:

- Coordination of the activities at the three levels is essential since the program must be implemented on a regional scale. Rodents invade crops from refuges and populations are re-distributed between crops via dispersal. Regional programs will prevent individual growers from inheriting a problem from neighbouring properties;
- The management program must be implemented every year. The potential long-term benefit will be lost if it is implemented for a few years and then neglected for a year or two because there do not appear to be any significant rodent problems. It must be realised that populations have the potential to increase rapidly at any time, given favourable environmental conditions;
- The objective of this program is to reduce the size of invading populations and the level of population establishment within crops. The full benefits of the program can be realised only when control extends throughout a region;
- Rodent control must be regarded as an integral part of farm management and, as for other farm practices, its priority for implementation should be judged on the expected benefit to production.

Table IV

Bait-base consumption under different conditions of population density and breeding intensity

Populaton class (1)	150-175	100-125	175-200	100-125	75-100	100-125
Pregnancy class (2)	0-5	5-10	5-10	10-20	20-30	20-30
Consumption (3)	29 (6)	26 (8)	20 (3)	25 (7)	26 (9)	25 (10)
No. sites	6	5	8	7	7	8

1 Population Index: no. animals per 100 traps

2 Pregnancy Index: % mature female stratum pregnant

3 Consumption Index: consumption, (g/unit population index/night) (s.d.)

RESPONSIBILITIES FOR SUCCESSFUL PROGRAM IMPLEMENTATION

Canegrower Responsibilities

- Eliminate in-crop weeds over the breeding season (December - April) through the use of herbicides and/or trash-blanketing.
- Keep crop margins weed-free since breeding animals from the crop will forage widely to obtain the nutrition necessary to maintain breeding condition.
- Where possible, manage grasslands by mowing or heavy grazing to render them unsuitable for use as "between crop" refuges.
- Where possible, convert grasslands into closed forest (for example, along creek banks and the slopes of steep, wet gullies).
- Encourage canopy closure in open forests. Do not burn open forests in an attempt to rid the area of rodents. Regular firing opens the canopy, encourages grass growth and provides rodents with a favourable habitat.
- Ensure that headlands and grass verges are closely mown over the June - January period to frustrate movement between crops.
- Bait individual canefields at the optimum time - December. A delay of one month can lead to significant damage.
- Clean up any undisturbed grassy areas around the farm and apply bait to these areas in December and July. Small areas can support large colonies of rodents.

Regional Responsibilities

- Implement monthly monitoring of rodent populations and weed cover between October and May.
- Assess damage prior to harvest to establish a database of correlations between population size, environmental conditions and subsequent damage. This data can then be interpreted at the industry level and used to predict the expected overall level of damage.
- Bait areas of specific damage potential based on the expected level of overall damage. For example, in a year where monitoring suggests that a high overall level of damage is expected, bait areas of high and moderate damage potential. In years where monitoring suggests that only moderate damage will occur, bait only areas of high damage potential. In years where low overall damage is expected, do not bait any areas.
- If the full suite of management recommendations are implemented, in many years baiting will not be necessary. Only in exceptionally rare circumstances would the baiting of low damage potential areas be necessary.

Industry Responsibilities

- Provide the expertise to establish early warning systems of potential crop damage (monitoring systems) for all major sugar producing districts that are affected by rodents.
- Provide the necessary expertise to interpret data arising from monitoring programs and provide an annual assessment of overall damage potential for each region.

- Recommend which areas of each district require additional control in the form of baiting.

- Coordinate studies to refine the location of low, moderate and high damage potential areas in each region.

- Implement studies to refine the control process in anticipation of changes in agricultural practice and bait registration requirements.

SUMMARY

- These studies have provided an understanding of the processes responsible for rodent damage together with specific management recommendations designed to reduce crop damage.

- Early warning systems of potential crop damage based on monitoring of rodent populations are now operating in the Herbert River and Mackay districts.

- A preliminary map of the Herbert River district based on divisions of low, moderate and high damage potential has been produced. This map will be refined by 1992.

- A preliminary map for the Mackay district will be available by 1992.

- A palatable bait-base has been developed for use when additional control is necessary.

CONCLUSION

The industry is now in a position to consider the implementation of a scientifically based, cost-effective and environmentally acceptable management strategy for the long-term control of rodents in sugarcane growing areas.