

# Rat Damage to Coconuts in Fiji. Part II Efficiency and Economics of Damage Reduction Methods

J. M. Williamst

Koronivia Research Station,

Department of Agriculture, Fiji.

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**Summary.** The effectiveness and economics of two commonly recommended methods of reducing rat damage to coconuts were examined.

Three replicated trials were used to investigate the effectiveness of a 30 cm wide aluminium band placed around the palm trunk 3.5–4.5 m from the ground. On palms only 9–10 m high these bands did not effectively reduce rat damage as senile fronds frequently bridged the bands, providing rats with access to the palm crowns. Bands did prevent damage on tall palms (over 15 m) since no bridging by fronds occurred.

A poison trial indicated that rat damage could be almost eliminated in a mature plantation for up to three months following one application of 3 kg/ha warfarin bait. This confirmed work carried out in Jamaica and the Gilbert and Ellice Islands.

The cost of control by the two methods was assessed in relation to four copra values and it was concluded, in view of the relatively low levels of rat damage that prevailed, that neither form of control would be worthwhile until the value of copra exceeds F\$150 per tonne and in the case of banding would only apply in the limited number of situations where bands are really efficient. PANS 21: 19–26, 1975.

## Introduction

Possible methods of reducing rat damage in Fiji have been considered since 1925 when Turbet (1925) suggested a widespread rat destruction programme using poisons, trapping and galvanised palm trunk collars. In 1932, Taylor also recommended the use of poisons, such as red squill, and discussed the possibility of employing various biological methods, including viruses. Taylor rejected the use of metal bands on the grounds that in his experience of them, in Tahiti, they required too much effort to prevent coconut fronds or other trees from bridging the bands.

Lassalle-Sere (1955) summarised the results of banding trials carried out in Tahiti in 1951. In sixteen plots of 50 palms each, four were banded with the remainder acting as controls. Twelve months data clearly showed that banding reduced damage in areas of tall mature palms surrounded by little undergrowth. Lassalle-Sere assumed that the reduction in damage produced a corresponding increase in yield but this data was later shown by Williams (1971) not to support this assumption. Between 1955 and the mid 1960's a large scale banding programme was carried out in Tahiti, financed by a levy on copra (Millaud, 1966). However, banding was discontinued in the late 1960's as it had not been shown that it resulted in an economic increase in copra yield (Millaud, personal communication, 1972).

Yelf (1966) advocated banding in Fiji using aluminium alloy, 30 cm wide. However he established neither the prevailing level of rat damage nor its effect on yields, which was probably why only limited areas of palms were banded in the following two to three years.

In Jamaica and the Gilbert and Ellice Islands (R. W. Smith, 1967; and F. J. Smith, 1969) it has been demonstrated that warfarin baits incorporating paraffin wax reduces rat damage in coconut plantations. Smith (1967) treated one area of 225 palms in Jamaica, where the damage was severe, and seven weeks after the first treatment found that damage was reduced from an equivalent of 32 to only two nuts per palm per year. However, no data were provided to suggest that any economic increase in yield resulted and banding was rejected on

<sup>1</sup>Present address Ministry of Agriculture and Fisheries c/o F.R.E.S. Box 106 Rangiora, New Zealand.

TABLE 2A. BANDING EFFICIENCY TRIALS WAINIYAKU ESTATE, TAVEUNI

1971 (11.7 months)			1972 (9.3 months)		
Plot number	Number of nuts rat damaged		Plot number	Number of nuts rat damaged	
	Banded	Unbanded		Banded	Unbanded
1	37	127	1	46	146
2	85	50	2	13	106
3	30	106	3	20	98
4	34	114	4	25	85
5	42	168	5	36	176
6	48	173	6	65	150
Mean damage per plot	46.0 ± 8.2	123.0 ± 18.4		34.2 ± 7.8	126.8 ± 14.5
Mean difference in damaged between banded and unbanded plots		77.0			92.6
Banding efficiency (percentage)*		63.0			73.0

TABLE 2B. VUNILAGI ESTATE, VANUA LEVU

1972 (5.0 months)				
Plot number	Number of nuts rat damaged		Number of nuts harvested	
	Banded	Unbanded	Banded	Unbanded
1	0	3	212	242
2	0	1	311	271
3	0	1	263	236
4	0	8	253	220
5	0	0	262	218
6	0	0	291	249
Mean damaged per plot	0	22	265 ± 13.8	239 ± 8.0
Mean difference in damage between banded and unbanded plots		2.2		
Banding efficiency* (percentage)		100		

\*See text for explanation of this term.

TABLE 1A. SUMMARY OF BANDING TRIAL AT TUVAMACA ESTATE TAVEUNI

1970-71 (12.6 months)						
Plot number	Number of nuts, rat damaged		Number of nuts harvested		Wet copra weight (kg)	
	Banded	Unbanded	Banded	Unbanded	Banded	Unbanded
1	82	105	666	771	212	250
2	119	123	760	530	247	233
3	85	130	919	924	290	305
4	83	108	1045	703	292	246
5	104	143	894	725	285	241
6	107	112	997	611	319	196
Mean per plot	96.7	120.2	880.0	710.0	274.0	245.0
s.e.	6.3	6.0	58.6	54.1	15.6	14.4
Mean difference in damage between banded and unbanded plots.	23.5					
Banding efficiency* (percentage)	19.5					

TABLE 1B

1972 (9.4 months)						
Plot number	Number of nuts rat damaged		Number of nuts harvested		Wet copra weight (kg)	
	Banded	Unbanded	Banded	Unbanded	Banded	Unbanded
1	41	66	506	690	179	234
2	151	65	635	486	208	162
3	76	85	693	580	225	202
4	84	42	817	550	250	204
5	111	91	827	625	277	224
6	114	86	737	503	253	165
Mean per plot	96.2	72.5	703.0	572.0	232.0	199.0
Mean difference in damage between banded and unbanded plots	-23.7					
Banding efficiency* (percentage)	0					

In the Gilbert and Ellice Islands Smith (1969) attached warfarin baits to palm trunks six feet from the ground and in one large scale trial (1450 palms in nine plots) reduced damage from the equivalent of 25 to one nut per palm per year, four weeks after poison application. In other trials in the Gilbert and Ellice Islands zinc phosphide baits were used in addition to warfarin but Smith, like other workers, produced no data to suggest any resultant increase in yield. Banding was found to be inefficient under atoll conditions, primarily because of corrosion caused by salt spray. Dense irregular stands of palms also meant that many bands were bridged by hanging fronds or other vegetation (Smith, 1969).

The first paper in this series (Williams, 1947a) describes the results of a widespread damage assessment programme in Fiji. This paper examines the effectiveness and economics of two commonly recommended methods for reducing rat damage to coconuts.

## Methods and results

### A. Banding

#### (i) Materials and methods

The use of mechanical barriers to prevent the scaling of palm trunks by rats is probably the simplest method of reducing damage and is particularly attractive since most rats in Fiji coconut plantations are not dependent on coconuts as a major source of food. Banding is a form of habitat manipulation that should not disperse a rat population by forcing it to turn markedly to other sources of food.

Yelf (1966) made considerable efforts to locate a low cost durable banding material and 0.15 mm thick aluminium alloy with a projected life of 20 years was chosen. Black sheet plastic, 0.25 mm thick, was also tested but was not considered suitable for widespread use as it becomes brittle with age and was thus easily damaged by wind or falling fronds. After cage trials with *Rattus rattus*, the larger of the two species attacking coconuts in Fiji, the other being *R. exulans*, Yelf established that an aluminium band 25 cm wide prevented rats from climbing palm trunks. However, to allow for non-vertical trunks he recommended 30 cm bands fixed by aluminium nails 4.5–5.0 m from the ground. This height was arbitrary but it placed the band above the thicker lower trunk (saving material) and avoided risk of damage by cattle or bridging by creepers. As considerable stocks of the 30 cm wide banding material used by Yelf were on hand in 1970 this material was used for all trials.

Three trials were established in 1970 to assess the efficiency of banding under general plantation conditions. Two were located on stands of younger palms (nine to ten metres high) as it was apparent at an early stage of the damage assessment programme that shorter palms incurred most damage (Williams, 1974a).

Trials on shorter palms were carried out on the island of Taveuni with one sited on Tuvamaca plantation and another on a property at Wainiyaku. At the former, palms were nine to ten metres high while at the latter they were 3.5–4.5 m. In addition a trial on tall palms (over 15 m) was established on Vunilagi Estate, Vanua Levu, on an area banded by the estate in 1968. At the Taveuni sites a uniform stand of 1000–1200 palms was divided into two and approximately half the area banded. Bands, depending on palm height, were placed 3.0–4.5 m from the ground. Six 20 palm plots were established within the adjacent banded and unbanded areas, all plots within each area being separated by at least one row of palms while there were six to eight rows between the plots in the two areas. Damage and production was recorded at Tuvamaca and Vunilagi but only damage was recorded at Wainiyaku.

All recording was done at monthly intervals. Tuvamaca and Wainiyaku plots were banded in January 1970, but recording was not begun until December 1970. The 11-month delay allowed production from the banded palms to recover at least partially from the effects of previous rat damage, for the time lapse from flowering to maturity is approximately 12 months.

#### (ii) Results.

At Tuvamaca in 1971 (Table 1) there was significantly less damage on the banded plots ( $F = 7.4$ ;  $p < 0.025$ ). Nevertheless the higher level of damage on the unbanded plots, which had probably been current for several years, did not result in significantly less production in either 1971 ( $F = 1.9$ ) or 1972 ( $F = 3.2$ ). This

TABLE 3. CONTROL COSTS IN COCONUTS AT A SERIES OF VALUES PER TONNET†

Loss/ palm year*	\$70/Tonne gross \$24/Tonne net			\$100/Tonne gross \$54/Tonne net			\$150/Tonne gross \$104/Tonne net			\$200/Tonne gross \$154/Tonne net		
	Net value of loss/ ha	Control feasibility		Net value of loss/ ha	Control feasibility		Net value of loss/ ha	Control feasibility		Net value of loss/ ha	Control feasibility	
		Poison	Bands		Poison	Bands		Poison	Bands		Poison	Bands
2	\$1.50	X	X	\$3.30	X	X	\$6.40	X	X	\$9.50		
4	\$2.95	X	X	\$6.50	X	X	\$12.80	X	X	\$18.85		
6	\$4.45	X	X	\$9.80	X		\$19.20			\$28.40		
8	\$5.90	X	X	\$13.10			\$25.60			\$37.90		
10	\$7.40	X		\$16.30			\$32.00			\$47.40		

† (Losses and costs per hectare per year)

\*Real loss after allowing for 50% compensation (see text)

NB

- 1) Cost of poisoning plus 8% per year for one year = \$8.22/ha/y where:—  
poison = 50 cents/kg (nine kg/ha/y)  
labour = 42 cents/h and 7.5/ha/y
- 2) Cost of banding plus 8% per year for 15 years = \$5.26/ha/y where bands costed at 30 cents each with a life of 15 y and 90% effective.
- 3) Palm density = 160/ha
- 4) Production calculated at 5,200 nuts/t and a yield of approximately 1t/ha/y (8 cwt/ac)
- 5) Production costs assessed at \$46.0/t
- 6) X indicates that control would not be economical

was not an entirely unexpected result in view of the known responses to rat induced nutfall, which enables palms to compensate for at least 50% of rat damage (Williams, 1974b).

Despite such factors, limited replication could have obscured a difference in yield between plots, therefore the standing crop (i.e. coconuts on the palm over four months old) was counted in March 1972. This method of yield assessment also showed that there was no significant difference between the yield of banded and unbanded plots ( $t = 1.8$ ;  $p > 0.05$ ,  $N = 240$ ).

Banding significantly reduced damage at Wainiyaku in both years (Table 2A) and completely eliminated damage at Vunilagi (Table 2B) although the damage was clearly very low in the whole area.

Banding efficiency (i.e. the reduction in damage produced by the presence of the band) can be illustrated by expressing the difference in damage between banded and unbanded plots as a percentage. For example, where bands prevent all damage the percentage efficiency would be 100. In the current trials efficiency ranged from zero to 100 percent with maximum efficiency being reached only on tall palms (Tables 1 and 2).

Bands clearly did not appreciably reduce damage on shorter palms and possible reasons for this were investigated. Senile fronds hanging parallel to the trunk, just before detachment, on palms with a trunk height of less than 12 m usually bridge the band (Fig. 1). Five monthly surveys of the Taveuni trials in 1972 showed that an average of three bands per plot and adjacent guard rows were bridged per month. Such fronds provide easy access to palm crowns which if contiguous enable numerous trees to be reached. The low efficiency of bands at Tuvamaca is possibly a reflection of palm density, which at 210/ha was considerably denser than the 110/ha at Wainiyaku. An almost complete canopy at Tuvamaca probably permitted more extensive crown movements by rats, once they had crossed a band, while the incomplete canopy at Wainiyaku reduced such movement, confining rats to the palm actually climbed. *R. rattus* and *R. exulans* were trapped on both properties and as the level of damage on the unbanded plots was similar it suggests that the rat population levels did not differ greatly between the two areas. However, once palms are tall enough for bands to be placed below the reach of senile fronds, i.e. when trunk height exceeds 10.5–12.0 m, the method is very effective as long as bands remain in good condition.

The durability of aluminium bands that had been in place on 235 palms for seven years was investigated on Wainiyaku estate in July 1971. Ten bands were missing (4.2%), possibly because of faulty installation, but more probably as a result of corrosion around the area of band overlap which, because it tends to be on the reverse slope of the trunk, is exposed to rain water draining from the palm crown.



Fig. 1 Aluminium band bridged by a hanging frond

Samples of corroded material were tested by the manufacturers (Astral Crane) in Australia. Traces of phosphates were found which could have been derived from animal excreta (birds, lizards etc.), decaying plant material (trunk lichens and ferns), soil, fertilisers or herbicides. These phosphates combined with moisture trapped under the band were considered by the manufacturers to be the main cause of corrosion, the impact of corrosion on band life being closely related to the thickness of the aluminium alloy. In a high rainfall area, such as Wainiyaku, most bands showed signs of corrosion after seven years of exposure. While it is difficult to estimate accurately the effective life span of a 0.025 mm thick alloy it could be expected that band loss due to corrosion would be unacceptably high after 20–25 years.

#### B. Poisoning.

Legislation governing the use of poisons in Fiji prevents the widespread use by unskilled personnel of acute poisons such as zinc phosphide. Trials, using various bait bases were therefore limited to the anticoagulant warfarin, during rat control studies on cocoa (Williams, 1973). Trials concentrated on the lowest priced commercial preparation (warfarin impregnated wheat, set in wax) as it is difficult for the average farmer to mix baits of grated coconut or similar material that prove consistently attractive to rats. In addition very few centres in Fiji have supplies of paraffin wax for producing a waterproof bait.

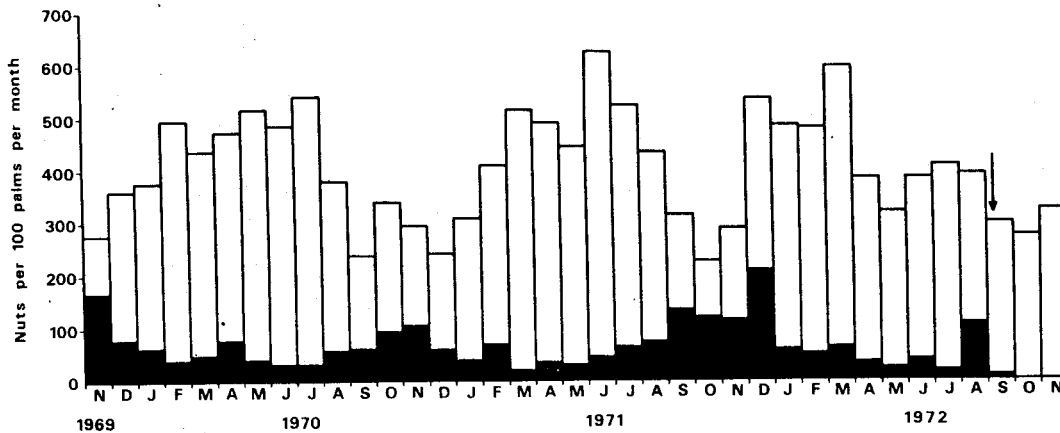


Fig. 2 Effect of rat poisoning on the level of damage. The arrow indicates poison laid, total height of histogram represents harvestable nuts, black represents both fresh and old damaged nuts.

Since bait acceptance trials in cocoa showed that the commercial paraffin/wheat preparation produced good results under most field conditions (Williams, 1973) it was used in a coconut trial primarily aimed at confirming the results of work carried out in Jamaica and the Gilbert and Ellice Islands. The trial site selected had been part of a long term damage survey and thus had a history of rat damage (Williams 1974a). When the survey was completed in August 1972, 30 palms (in the 100 palm plot) with a history of regular rat damage were selected and 115 g baits tied to the trunks 2.75 m from the ground. Palms favoured by rats were used as bait points in an attempt to ensure maximum rat/bait contact and thus increase the effectiveness of poison applications. Since very few of the baits had been attacked during the five days after laying they were all transferred to the palm crowns as the trunks may have been an exposed feeding position. In the following 10 days 2.5 kg of bait were eaten and no damage recorded until 12 weeks later. This marked reduction was attributed to the poison, for in the years 1969 to 1972 damage on the plot rose noticeably in the last three to four months of each year. Poisoning thus clearly reversed this trend in 1972 (Fig. 2).

This trial indicated that damage can virtually be eliminated for up to three months in a plot of one hectare. A possible limitation is the apparent need to place baits in the palm crowns, although it should be noted that in the Gilbert and Ellice Islands Smith (1969) obtained good results with baits placed on trunks, possibly because of the absence of predators such as the Barn Owl (*Tyto alba*).

Provided there is no danger to domestic livestock and interference by crabs is limited, ground-placed baits should give good results even if bait consumption is increased by *R. exulans*, a species that causes less damage to coconuts than *R. rattus* since it does not forage in the crowns of tall palms as frequently as the latter.

Since trials in cocoa (Williams, 1973) suggested that approximately 30 bait points per hectare provided good control, a similar spacing would probably be satisfactory in coconuts. Thus three applications per year, at a rate of 3 kg/ha per application would on the basis of cocoa trials give satisfactory control.

Smith (1967) recommended three to four 6 kg applications of an anticoagulant block per hectare per year for Jamaica plantations, but no allowances were made for waste or the drop in consumption that occurs when an area is poisoned over a number of years (Williams, 1973). Smith (1969) similarly considered necessary an application rate of 6 kg/ha of an anticoagulant block but considered repeated applications could be governed by subsequent damage levels.

#### Control costs in coconuts

The 1969 to 1972 survey of rat damage in Fiji revealed levels ranging from zero to 9.2 nuts per palm per year, with mean damage per palm per year at all sites being 5.4 in 1970, 3.9 in 1971 and 2.5 in 1972 (Williams, 1974a). However a trial to investigate the effects of known levels of simulated rat damage, on palm productivity established that there was an increase in female flower production, and no apparent decrease in the number of

harvestable coconuts produced even before the flower increase could influence yield; responses to the loss of developing coconuts that were conservatively estimated to compensate for 50% of the nuts attacked (Williams, 1974b). Thus the damage levels quoted above have to be reduced by approximately one half in order to represent an actual production loss.

Table 3 presents the practicability of rat control methods in coconut plantations in Fiji. Since corrosion may cause high loss over a longer period the installed life of aluminium bands has been set arbitrarily at 15 years. The installed cost of bands was derived from estate accounts in 1971 (Morris Hedstrom Ltd.). The capital costs of bands plus interest have therefore been spread over 15 years which, while producing a lower cost than poisoning, has serious disadvantages. For example it has been shown (Williams, 1974a) that loss varies considerably from year to year while the gross value of copra can range from Fiji \$75/t (mid 1972) to Fiji \$250/t (September 1973). These two factors make costing on a 15 year basis very difficult but do not seriously affect a 'short term' (two to three years) control method such as poisoning.

### Conclusions

It is evident from the above damage survey figures (after allowance has been made for palm compensation) that nut loss, even in areas of highest damage did not exceed four to five nuts per palm per year. At these relatively low levels neither form of control would be worthwhile until the value of copra exceeds Fiji \$150/t and in the case of banding would only apply in very limited situations. That is, palms would have to have vertical trunks 10.5–12.0 m high (not achieved until at least the 25th year), be evenly spaced and have no vegetation that could cause bridging of bands. Poisoning does not have such severe limitations, but a decision to control using this method has to allow for changes in the level of damage, copra yield and value over at least a two year period.

The final decision on whether or not to reduce rat damage must be governed by the size of the affected area and the overall efficiency of the plantation unit in addition to the level of damage, copra yield and value. Clearly where a percentage of the nuts are lost in secondary bush on the plantation floor, as occurs on some Fiji plantations, control is of little value.

Reduction of rat damage in Fiji coconut plantations would, in view of the number of variables, be of marginal value at current levels of damage. Only if the average level rose significantly and the value of copra remained at over Fiji \$200/t would widespread control be economically sound.

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