The Effect of Artificial Rat Damage on Coconut Yields in Fiji

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Summary. In all cases assessed yield loss from rat damage in coconut plantations has been based on counts of immature damaged nuts, it being assumed that yield loss was directly proportional to the number of nuts attacked. Insect attack on coconuts and other crops has indicated that compensation for pest damage can occur, hence counts of immature damaged coconuts were unlikely to be directly related to yield loss. A trial involving artificial rat damage at four intensities was therefore established to investigate the relationship between damage and yield. Several possible compensatory modes were investigated and two responses were noteable: 1. The number of female flowers increased in response to the loss of immature coconuts but this compensatory response could not influence the number of harvestable nuts until 23–24 months after damage started, since this represents the time lapse from flower formation to nut maturity. 2. There was no apparent decrease in the number of harvestable nuts produced by the highest levels of artificial damage and it was postulated that there could be a decrease in late immature nutfall caused by factors other than rat attack, since the flower responses were ineffective within the two years.

In addition it was found that coconuts favoured by rats contained 23.9–29.2% of the dry matter of mature coconuts, suggesting that 70–75% of the material resources that would have been expended on the coconuts lost could be deployed in replacements.

It was concluded that the upper limit of compensation was probably 75% of the number of nuts damaged but because none of the compensatory responses are fully understood it was considered that 50% compensation would be a realistic level. Counts of immature damaged nuts should therefore be halved to represent yield loss.
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Introduction

Rat damage to coconuts has been studied in several parts of the world in the last 40 years and available accounts have been reviewed by Williams (1971). Damage is mostly caused by various subspecies of *Rattus rattus* (Smith 1967, Smith 1969, Williams 1974) but *Rattus exulans* is important in some of the Pacific Islands (Wodzicki, 1969, Smith, 1969). Damage usually consists of a single hole in the husk of the immature fruit with most occurring between the fourth and eighth month of development, which is before significant endosperm is laid down. A damaged nut detaches from the inflorescence two to six days after attack (Williams 1974).

Earlier surveys of rat damage (Taylor, 1930; Paine, 1934; Smith 1967; Smith, 1969) have given little consideration to the relationship between the number of nuts attacked and copra yield since it has generally been assumed that the relationship between the damage symptom (green holed nuts) and yield is direct. This assumption is questionable since it does not allow for the possible physiological impact that early nut removal could have either on the development of remaining fruit, or subsequent flowering and fruit setting (Williams, 1971). The coconut palm normally produces more female flowers than develop to maturity and in the first few months some fruit are shed in a natural thinning process which is thought to keep the crop within the resource limits of the palm (Menon and Pandalan, 1957). Many factors such as nutrition, climate and insect attack affect this process.

Compensation for insect attack on the foliage of grain crops has been recorded by White (1946) and Davidson (1965). They simulated grasshopper injury and found that the stage of wheat, when attacked, and type

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of injury governed the reduction in yield. Attack early and late in the growth cycle caused the greatest loss (13–28%) while during the stage of maximum growth loss was minimal (4–10%). In contrast, rat attack on the foliage of young sweetcorn was found to have less effect on final yield than the initial loss of plants had suggested (Judenko, 1967). The remaining plants produced more and larger cobs.

Vanderplank (1959) and McKinlay (1965), working on the coconut palm, both demonstrated that there is a complex relationship between yield (i.e. harvestable nuts) and damage, the latter inflicted by the coreid bug *(Pseudotheraptus wayi* Brown*)* in the first three months of nut development. McKinlay (1965) found that reduction of this damage produced only a slight and transient increase in yield. From this result he concluded that the palm, by variations in physiological shedding or in the number of female flowers produced, adjusts its crop production to currently available resources.

In view of the clearly complex relationships between the level and stage of pest attack, Williams (1971) postulated that rat induced nutfall, which occurs at a later stage of development than the insect attack discussed above, could affect the palm in three ways:

a Premature removal of nuts by rats could result in an increase in flower production.

b Premature removal of nuts might affect nut setting rate.

c If there is a reduction in the total number of nuts on the palm the remaining fruit could produce more coconut flesh (termed copra when dried).

Any of these possibilities could result in smaller yield reductions than simple counts of immature damaged coconuts would at first suggest, so a trial was established to determine the relative importance of each. This was achieved by causing artificially several levels of rat damage, this approach being necessary because the level of naturally occurring rat damage was so variable, the major factor being a marked concentration of rat attack on a limited number of palms (Williams, 1974). Since the basis of this selection was not known when the trial was started in 1970, yield from the type of palm favoured, in the absence of rat attack could not be determined. Artificial simulation of damage is a recognised method of estimating the relationships between pest damage and crop loss (Judenko, 1965). It has been used with plants as diverse as beet (Jones *et al*, 1955) and pine trees (Austara, 1970).

Method

The trial was established in October 1970 on Maravu Estate, Vanua Levu Island and continued for two years. All palms in the areas selected were 14–18 m high, aged approximately 40 years and situated on a coastal strip of nigrescent soils (Twyford and Wright, 1965). Foliar analysis in the study area revealed a general nitrogen deficiency which normally results in low female flower production (Fremond *et al*, 1966).

Preliminary individual yield recording of most palms in the 3.3 ha area was carried out. All bunches over approximately three months of age (mean length of 11 cm) were observed from the ground using binoculars, and the numbers of nuts recorded. As such a count approximates to a years production this provided a measure of palm yield variation, enabling the optimum number of palms/treatment to be determined. Five groups of 40 palms each were assigned within the range 30–70 nuts/palm, each group having a mean of 45 ± 1.4 nuts/palm. In view of the S.E. 40 palms (replicates)/group were considered sufficient, particularly as all replicates of all groups were distributed at random throughout the 3.3 ha.

Rat damage observed on a total of 910 palms at 10 sites over a 12 month period was used as a basis for establishing four levels of simulated rat damage. It was found that only three percent of the palms lost more than 24 nuts/year and that the mean loss was 5.4 nuts/palm. Thus, four damage rates of 6, 12, 18 and 24 nuts/palm were chosen, the aim being to span the full range of damage encountered in the field.

Rat damage was simulated by punching a hole in the green nut with a 2 cm diameter steel cork borer, a satisfactory method for nuts up to about eight months of age, after which the developing husk becomes too hard to penetrate. This form of damage caused all coconuts to fall within eight days. Rats were known to favour coconuts aged three to seven months, that is bunches number four to nine (Williams, 1974), so simulated damage levels in the trial were concentrated on these. Accordingly 30% of the artificial damage was assigned to bunch five, 61% to bunch seven and 7% to bunch nine. Husk hardness prevented the damaging of nuts from bunches older than number nine. The annual distribution of the four simulated damage levels was calculated on a monthly basis (Table 1). Bunch number one in the system used was always the youngest visible and also the highest in the palm crown. Bunches five, seven and nine are at successively lower levels and become the sixth, eighth and tenth bunches respectively as soon as a new bunch unfolds. This system of bunch numbering from the youngest towards the oldest each month ensured that simulated damage was confined to the naturally favoured size classes.