

# OBSERVATIONS ON RAT DAMAGE TO COCONUTS\*

## 1. INTRODUCTORY

**I**T is common knowledge that rats do a considerable amount of damage to coconut estates in many tropical countries. In Fiji, their importance to the coconut planter has been remarked on by several investigators during the last ten years—notably by Taylor and Surridge.

Estimates of the damage are given by Turbet as 10 per cent., and by Taylor as 6.85 per cent. These writers record estimates by certain planters of rat damage amounting to 50 per cent. and 30 per cent. locally, but they are cautious in the acceptance of these figures.

Taylor is the first scientific investigator to have made a statistical survey of rat damage to coconuts in Fiji, and his estimate of about 7 per cent. for the whole group was compiled from data derived by counts of immature and mature coconuts on the tree, for 460 trees in twenty representative estates in Fiji.

In estimating rat damage, Taylor assumed that practically all those nuts which fall from immature fruit branches older than the fourth (counting the youngest open branch as number one), are damaged by rats. This assumption is tenable, in spite of the fact that largish, green nuts, bearing no signs of rat damage may often be found lying on the ground. The apparent abundance of these large, immature nuts is due to their not being collected by copra cutters; so that they accumulate and suggest that their fall is brought about by some relatively important and definite factor amongst those which operate to reduce the numbers of maturing fruits. Actually the fall of many such nuts is brought about by rats, although no tooth marks are to be found on the nuts themselves. But the majority fall off for a number of obscure reasons, probably largely physiological, operating through the medium of the tree itself. These are included in what Taylor refers to as "normal nutfall".

Taylor's estimate of rat damage to coconuts in Fiji was, therefore, made by an examination of fruit still on the tree. The writer, on the other hand, estimated rat damage by counting nuts which had fallen to the ground, as well as by Taylor's method. The results differ so strongly from those obtained by Taylor that it is desirable that the figures be published and this alternative method of investigation described.

The extent of the damage done by rats varies considerably in different localities. The writer's principal investigations were made near sea-level on Ura Estate (Taveuni). This is a large estate, and such estates are

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claimed by Taylor to suffer relatively little rat damage. But in the opinion of the writer, who made comparative notes of the abundance of rat-bored nuts in many parts of Taveuni and other islands, rats were certainly not less in evidence at Ura than in most other places.

At Nabavatu, in Lau, rat-bored nuts were lying about the ground in far greater relative abundance than on Taveuni. But the yield of mature nuts on Nabavatu was, at the time (December, 1933), much reduced, owing to past ravages of the Coconut Leaf-Miner; so that the comparative scarcity of mature, undamaged nuts on the ground may have produced an exaggerated impression of the normal rat damage on that estate.

It is interesting to record here, in comparison with Nabavatu, that on Kanacea, an island only twelve miles distant, there are no rats. The present manager of this estate has energetically guarded against the landing of rats from ships calling at Kanacea, and on at least one occasion, succeeded in intercepting would-be colonies brought ashore inside packing cases.

The writer paid three visits to Vunilagi Estate (Vanualevu) during the early part of 1934, and there, fallen rat-bored nuts were found to be as plentiful as at Ura. Taylor's figure for rat damage on Vunilagi in 1929 was 4.17 per cent.; but he says that this was too high a figure for the whole estate, in which the manager estimated rat damage at only one per cent. It is possible that more damage is done some years than others. If this is so, one would expect rats to open more coconuts during a dry than during a wet year, since they appear to bore into nuts solely for the liquid contents. But 1933 was a wet year, and rainy weather continued with little interruption for the first six months of 1934, so that the rat damage evident on the occasions of these recent visits is not likely to have been abnormally high. The manager of the estate agreed that rat damage was more severe than he had formerly supposed. These instances of recent personal observations in places outside Taveuni, the number of which could be multiplied considerably, are included to bear out the writer's conviction that the damage done by rats to coconut estates in Fiji is very generally severe, and that the figures appended below, all of which were derived from a two and a half acre block of land on one estate, are representative of many parts of the Colony.

## **2. ANALYSIS OF RAT DAMAGE ON COCONUT ESTATES**

During the course of eighteen months' field work on coconut estates, it was observed that rats may cause damage to the coconut crop in many different stages of its development. From the time just before the spathe opens until the time any copra produced therefrom is shipped from the estate, damage by rats may take place. The following are the principal ways in which rats may cause damage to this crop.

### **I. CHEWING THROUGH THE INNER SPATHE BEFORE THE LATTER BURSTS**

Taylor remarks on this, but discounts any detrimental effect on the score that only the male flowers are damaged. In 130 youngest spikes from four estates on Taveuni examined by the writer, 42 per cent. of the inner spathes were chewed through in one or more places by rats.

It is true, as Taylor points out, that the rat-borings are usually near the extremity of the spathe; but in a few instances, holes were found near the base, and female flower buds had been damaged.

It was frequently noticed that, although a large portion of the inner spathe had been chewed away by rats, no rat damage could be detected in the flowers lying immediately inside the holes thus made. It was also noticed that rat-chewings were often associated with the round scars made by mature larvae of *Acritocera negligens* when emerging from the flowers in a spathe. It is not improbable that rats may feed on these large, fleshy larvae, and in this way actually play a beneficial part in helping to reduce the numbers of this minor pest. Proof of this hypothesis was not, however, obtained.

The damage done by rats at this stage of a coconut's development is infinitesimal compared with that done later on; but it calls for remark in so far as it provides additional proof of the very widespread occurrence of rats amongst the trees of a coconut plantation.

## **II. DAMAGE TO THE FLESHY AXILLARY PADS OF THE LATERAL FLOWERS, BRANCHES (SPIKELETS) AFTER SPATHE HAS BURST**

In the 130 spikes already mentioned, 8 per cent. of the spikelets showed stems damaged by rats. The base of a "spikelet" is thickened and composed of soft and juicy tissues. Rats gnaw this part of the flower branch apparently in an effort to obtain moisture. Spikelets badly damaged in this way sag and are unable to support the weight of the maturing nuts. It would be difficult to compute exactly the percentage of the crop destroyed in this way; but it would certainly not be more than one per cent.

## **III. FEMALE FLOWER BUDS DAMAGED AFTER THE SPATHE BURSTS**

Not infrequently, it was found that rats had chewed away a portion or the whole of a young female flower. It appeared that, in the majority of cases, such damage had been inflicted after the spathe had burst open.

For the first few days after opening, the spike contains female flower buds which are comparatively soft and juicy. Rats probably gnaw these, as they do the axillary pads of spikelets, to get moisture.

Although the writer never saw rats in the act of eating young female flowers, there is no doubt that a certain type of injury, not infrequently found in the female flowers on the first open flowering branch is the work of rats. Three per cent. of the female flower buds in the 130 spikes examined bore damage attributable to no cause other than gnawing by rats; and the total damage inflicted by rats at this stage is certainly

represented by not less than 3 per cent. of the female flowers because, in computing that figure, all those flowers which were damaged, or had fallen off from some indeterminable cause, were included as not damaged by rats.

The total amount of damage caused by rats to flowering spike before that stage of its development at which the fruit set is almost negligible, compared with that which takes place during the later stages of fruit development.

To refer again to the 130 first-flowering branches examined on Taveuni, it was found that on no less than 51 per cent. there were definite traces of rat damage. These spikes were cut from trees growing both near to and far from houses; some near sea-level, and some near the top boundary fence of an estate. They show that rats forage over, even if they do not nest on, at least half of the trees on a plantation.

#### IV. DAMAGE TO YOUNG FRUITS

Most of the damage done by rats to the coconut crop takes place at the various stages of fruit development between pollination of the female flowers and the final maturing of the fruit. Shortly after the fruit is set, a cavity begins to form inside it, in which nutrient fluid accumulates. Rats bite through young nuts at the base in order to obtain this fluid, and in so doing dislodge them from the tree. In many cases, the husk of a nut is incompletely penetrated before the latter falls to the ground, in which case the rat's thirst remains unslaked, although damage has been done. Rats are thus extravagant drinkers, in so far as coconuts are concerned, wasting by clumsiness or inexperience, much that they could use.

Any nut which, as a result of injury by a rat, falls to the ground before the husk has begun to turn brown, is rendered unfit for harvesting, and these nuts, most of which are completely bored by rats, are common objects in coconut estates on any island in Fiji where rats are established.

The rather ragged-edged, round holes, either at the side, or more usually near the base of such nuts, are so characteristic that in counting nuts lying on the ground, there is no possibility of mistaking those whose premature fall has been brought about by rats.

Taylor writes, "Rats very rarely attack young nuts. They attack the three-quarter grown nuts chiefly." This is largely true, but it is necessary to qualify, or render more explicit, the phrase "three-quarter grown."

In order to fix the exact position on a tree from which rat-bored nuts had fallen, the writer investigated the progressive growth in size of coconuts picked from a sample tree growing within the two-and-a-half acre block investigated at Ura. The length in inches of the female flower buds or fruits from successive spikes on this tree was as follows:

Spike	Size of Female flower or fruit	Colour of husk
1	$\frac{5}{8} \times \frac{7}{8}$ inches	Pale-yellow (5 flowers $> \frac{1}{4}$ off)
2	$1\frac{3}{8} \times 1\frac{3}{8}$ ,,	Light-green (5 flowers all off)
3	$2 \times 1\frac{1}{2}$ ,,	Dark-green.
4	$3\frac{1}{2} \times 2$ ,,	,,
5	$4\frac{1}{4} \times 2\frac{1}{2}$ ,,	,,
6	$5\frac{3}{4} \times 3\frac{1}{4}$ ,,	,,
7	$6\frac{1}{2} \times 4\frac{1}{2}$ ,,	,,
8	$6\frac{1}{2} \times 5\frac{1}{4}$ ,,	,,
9-18	$\pm 7 \times \pm 6$ ,,	,,
19	$7\frac{1}{2} \times 6$ ,,	Pale-brown (mature).

In order to check the value of the figures from this tree as being average for the whole area, a nut from the sixth spike of twenty other trees in the same block was measured, and the number of immature open fruit branches (spikes) counted. The average length of the young nut on the sixth spike was found to be  $5\frac{3}{4}$  inches (maximum  $7\frac{1}{2}$  inches, minimum  $4\frac{3}{4}$  inches). This agrees exactly with that of the sixth nut on the above sample tree. The average number of immature spikes was fourteen for twenty trees, so that the sample tree had five more such spikes than the average.

A study of these figures will make it evident that a nut is three-quarters grown in size when it is less than half ripe. In other words, the time taken for a newly-pollinated female flower to grow to full size is only half as long as the time it takes to become mature. Thus, when reading Taylor's statement that rats prefer the three-quarter grown nuts, one must bear in mind that such nuts are really less than half mature, and would occupy about the seventh spike on an average tree.

Although the writer agrees that this stage of nut is very commonly found to have been bored by rats, it was seen at Ura that large numbers of full-grown nuts were bored. Even nuts with the husk beginning to turn brown were on occasions found to have been bored. A number of the largest rat-bored nuts found on the ground in the experimental block were traced to the following positions on five trees:

Tree	Rat-bored nuts fell from spike Nos.	Total No. of green spikes on tree
1	9, 11 and 12	15
2	9	10
3	8	13
4	7 and 8	12
5	9	12

These nuts had fallen to the ground not more than ten days before the above data concerning them were obtained. It is thus evident that rats may cause immature fruits to fall from a number of successive spikes at any one time.

Out of 1,121 fallen rat-damaged nuts, counted over a period of four successive months, in the test block at Ura, 245 (or about 20 per cent.) were small, thin nuts, less than five inches in length. These fell from some two or three spikes at the most, represented by numbers three to five on the average tree.

Such small nuts were not included in the total of rat-bored nuts used in calculating the percentage damaged, since it is considered that their fall may be offset by a subsequent reduction in normal nutfall. But, once a nut is full sized, it would seem unlikely that its premature fall would result in any great saving of food materials in the tree, and thus not tend to be compensated by any increased amount of fruit later on.

As soon as a nut matures, and the husk turns brown, rat damage ceases; because, even if such a nut is nibbled at by rats, sufficiently to cause it to fall as occasionally happens, it is ripe enough to be used for making copra.

From the information set forth above concerning the spikes from which the maximum size rat-bored nuts fell, it can be calculated that on an average tree in the test block, *i.e.*, one with fourteen immature, open spikes, rat damage ends on about spike ten. It may, therefore, be concluded that rat damaged nuts of more than five inches in length are falling each month from each of the spikes between the sixth and the tenth, on an average tree in the area under consideration.

It will now be convenient to describe the methods adopted by the writer in procuring the data used in the estimation of rat damage.

An area of land, a little over two-and-a-half acres in extent, surrounding the fence which enclosed the overseer's compound at Ura, was weeded and cleared of all fallen nuts and split husks at the beginning of May, 1934.

At the beginning of each of the four subsequent months, the fallen nuts were again examined and counted over this area.

Apart from the nuts which fell prematurely and yet bore no evidence of rat damage, all the nuts lying on the ground were counted, irrespective of size. These consisted of rat-damaged nuts and mature nuts, none of which had been removed from the test area before their numbers were checked by the writer at the end of the month.

As has already been explained, the rat-damaged nuts were divided into groups; *viz.*, those whose length was less than five inches, and those whose length was greater than this. All nuts which could be cut for copra were classed as "mature", even if they bore evidence of rat damage.

The figures obtained were as follows :

**TABLE I**

Rat damage at Ura, Taveuni. Estimated by counting nuts on the ground in an area of  $2\frac{1}{2}$  acres (143 palms) :

Months in 1934	Rat-damaged nuts			Mature nuts	Total nuts 5 inches or more in length
	Less than 5 inches in length	5 inches or more in length			
May	99	278	957	1,235	
June	82	261	464	725	
July	27	165	373	538	
August	37	172	376	548	
Totals	245	876	2,170	3,046	
Average per month	61.2	219	542.5	762.5	

These figures show that in a period of four months, during which 51.71 inches of rain fell—twenty inches more than the average for the previous five years—876 large nuts fell prematurely owing to rat damage, and 2,170 fell in a sufficiently mature condition to be harvested.

The estimation from these figures of that percentage of the potential crop which was destroyed by rats is a simple matter, because it is quite justifiable to assume that every large rat-damaged nut found on the ground would have matured in the absence of rats. Thus, for each month of the four during which observations were made, an average of 219 potentially mature nuts were prematurely destroyed by rats. During the same period, it was found that an average of 542.5 mature nuts had fallen per month.

Now the number of mature nuts falling between May and August is probably higher than at other times of the year; moreover, the number of nuts bored by rats during that period in 1934 is not likely to be more than at other times of the year, because the rainfall was unusually heavy, and rats are thought to bore more nuts in dry weather. Therefore, it is estimated rat damage at a conservative figure to assume that a monthly average of 542.5 mature, and 219 rat-damaged nuts, are falling all the year round.

It is thus evident that the potential monthly crop in the absence of rats is 542.5 plus 219 nuts for 143 palms in the two-and-a-half acre experimental plot under review. Therefore, out of a potential crop of 761.5 nuts, 219 are destroyed by rats. This represents a loss amounting to 28.76 per cent. The discrepancy of over 20 per cent. between the figure for rat damage given by Taylor and that derived from the writer's more recent investigations is sufficiently large to demand the closest scrutiny of the methods employed. The writer would, in fact, be very reluctant to publish such a large figure as representative of rat damage in Fiji were it not for the fact that he obtained other supporting data by the same method as that employed by Taylor, with which to check the results.

It might be objected that rat damage over such an area as that chosen, which was near to sea-level and to human habitation, is likely to be misleadingly high if the figure is claimed to represent rat damage all over an average Taveuni estate. But in the light of the following information derived from diverse situations in four widely separated localities, such an objection cannot be entertained.

In the investigation of Tirathaba damage, carried out by the writer in August and September, 1934, counts were made of the young nuts on branch IV, and of the mature nuts on the last six branches of 100 palms in four localities. The information obtained, which has a bearing on the subject of rat damage is set forth in the following table:

**TABLE II**

Rat damage to young coconuts in Fiji, as estimated by counts of nuts on the palm:

Locality	Approx. height in feet above sea-level.	Approx. distance from nearest house.	No. of trees examined.	Average height of trees examined.	Average No. of young nuts on branch IV.	Average No. of mature nuts per branch on last six branches.	Percentage of crop damaged by rats.	Percentage of youngest spikes showing evidence of rat damage.
		ft.		ft.				
Ura ...	150	100 yds.	40	38	7.74	3.87	42.6	63
Vuna ...	150	$\frac{1}{4}$ mile	22	46	6.80	3.67	46.0	59
Nalele ...	400	$\frac{1}{2}$ mile	17	38	7.27	4.91	31.1	41
Nacaugai ...	10	$\frac{1}{3}$ mile	21	49	5.06	3.41	32.6	10
Average (for Taveuni)	Various	Various	100	42	6.47	3.96	38.07	43
Taylor's figures for Fiji as a whole, 1929	Various	Various	460	40	4.365	4.066	6.85	—
Taylor's figures for average of 3 estates on Taveuni, 1929.	Various	Various	60	40	6.07	5.66	5.11	—

In counting the nuts on the last six branches, the writer included those mature nuts which had fallen off, as well as those remaining on the tree. Taylor does not state whether, in counting mature nuts, he included those which had already fallen; but it is important to emphasise that the writer's estimate of mature nuts is a maximum estimate. The counting of young nuts remaining on branch IV is a simple matter, allowing no scope for error through variation of the personal factor. So that the figures for rat damage derived in this way in 1934 are strictly comparable with those derived by Taylor in 1929. The discrepancy in the results can only be accounted for by supposing either that rat damage has increased very considerably during the last few years, or else that there is a very great

seasonal variation in the extent of rat damage, and that Taylor's figure in April for mature nuts from spikes which would have been subject to rat attack from about the previous October to February, is not strictly comparable with those obtained by the writer in August for mature nuts on spikes which would have been attacked by rats from February to June.

Quite possibly it may be found that rats have seasonal migrations to and from palms in Fiji, and that it would be necessary to carry observations over a period of at least a year in order to make an accurate estimate of the damage which they cause.

But, with the support of the very high percentage figures for rat damage on Taveuni shown in Table II, derived by Taylor's method of counting nuts on the tree, the writer has no hesitation in presenting the figure of 28 per cent. as a minimum for rat damage from May to August, derived from a count of nuts which have actually fallen to the ground.

## V. DAMAGE COPRA AFTER HARVESTING

Rats swarmed over the "vatas" (copra drying trays) at Ura. The writer is unable to supply any figures showing the extent of damage to copra during the progress of drying and storage before shipment; but chewed pieces of copra with tooth marks of rats are in sufficient abundance on vatas to indicate that rat damage to the crop at this stage of its development is far from negligible.

### 3. Total damage caused by rats.

In the previous section it has been shown that rats damage the coconut crop in at least four stages of its development, viz. :

- (i) before the spathe bursts;
- (ii) after the spathe bursts, but before the fruit has set;
- (iii) after the fruit is set, but before it is mature;
- (iv) after harvesting—during the drying and storage of copra.

The damage brought about in stages (i) and (ii) is not more than of the order of 1 per cent. of the crop—the exact figure being impossible to estimate without further extensive investigation. The damage occasioned in stage (iii) is that most easily computed, and is shown to be about 30 per cent.

The writer would not be surprised to learn that over 5 per cent. of copra destroyed by rats during the time it lies on vatas and in sheds awaiting shipment from the plantation.

There is obviously scope for further statistical investigations of rat damage. The damage done one month may well be less extensive than that done in another, but from the figure obtained, and the field observations made on Taveuni, it appears likely that at present rats are destroying something like one-third of the total potential copra at various stages in its preparation.

#### 4. CONCLUSION

Rat damage to coconuts in Fiji has, in the past been greatly underestimated, or else it has become very much more severe than it was five or more years ago.

From being a serious minor pest of coconuts, rats are shown by the writer's recent investigation on Taveuni to belong to the status of a major pest of this crop.

With copra at its present market value, it is perhaps inopportune to attempt control of this pest, but when times improve, the question of rat destruction should be given earnest attention.

At present, little is known concerning the bionomics of the rats which inhabit coconut plantations in Fiji, and this matter requires early investigation. The only approved methods of control which suggest themselves as being practicable under Fiji conditions are trapping and poisoning.

The satisfactory prosecution of either of these methods entails a considerable recurring expenditure, and it would appear not improbable that with the aid of a thorough knowledge of their habits, some more economical and thorough method might be discovered of destroying rats in coconut plantations.

The available information already at hand suggests that rats may be governed in their feeding habits by climatic factors; and it would appear possible that with the provision of some alternatives in the way of food supply, sources of moisture, nesting sites and so forth, rats might be induced to forsake coconut palms and satisfy their appetites in some way other than by the wholesale destruction of young coconuts.