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SIZE AND WEIGHT OF COCONUTS DAMAGED BY RATS

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To determine if several Philippine varieties of palms compensated for rat damage by producing larger or heavier nuts, 60 nuts, taken randomly were measured from those harvested in a plot (A) that had been effectively treated for rat damage for 21 months, and the measurements compared with those of 60 nuts taken from a plot (B) that suffered chronic, heavy rat damage. Based on one-sided Student's *t* tests, fresh and dry (i.e., copra) weights of the endosperm of nuts from Plot B were slightly but significantly ($ps \approx 0.05, < 0.005$, respectively) greater than those of nuts from Plot A. However, based on strength of association tests, only about 7% of the variance in copra weight and only about 2% of the variance in fresh endosperm weights were due to the presence or absence of rat damage. Thus, compensation by increased copra content of undamaged nuts played at most a minor part in the differences in weights of nuts that we observed between the experimental plots. The differences were unimportant in assessing the economic benefits of the control used in plot A.

INTRODUCTION

Individual palms might be able to compensate for coconuts that are damaged by rats. Compensation of economic interest to growers could logically occur in only two ways: i.e., (a) by at least partial replacement of damaged nuts with undamaged nuts by harvest time (Williams, 1974a), thus reducing the impact of rat damage on yield (defined here as the number of harvestable nuts per tree per month); or, (b) by increasing the size and weight of the copra content of the undamaged nuts, thus lessening the impact of rat damage on copra harvested without influencing the impact on yield. Compensation, if it occurs, could be an important factor in assessing the effects of rat damage on coconut production, and the economic benefits of control programs. In studies conducted on the Fiji Islands, Williams (1974a) reported that yields of palms suffering heavy rat damage were similar to those of palms having little damage. From a trial in which rat damage to mature nuts was simulated by boring holes into growing nuts, Williams (1974b) found that female flower production increased, that yield remained stable, and that trees could fully replace damaged nuts by harvest time when even 50% or more of the nuts were artificially damaged.

In contrast, our study (Reidinger and Libay, in press) reported significant increases in individual tree yields when effective rat control was practiced on 4 experimental plots in the Philippines. The plots, 1 ha each, contained local varieties of palms. Two of the plots were treated during the first year of the study, and all were treated during the second year. For treatment, bait containing an anticoagulant rodenticide was placed monthly in the crowns of 25% of the trees within the plots. In plots baited for 2 years, yields of harvestable nuts averaged 7.4 during treatment; in plots baited for 1 year, yields averaged 6.0 during treatment. Yields were about 150% greater than the pretreatment yields of 2.9 and 2.6, respectively. During a third year continuation of the study, yields were about 180% greater than the pretreatment levels. The study has since been replicated and, although fewer than 25% of the trees were baited in the replicates, similar increases in yield were measured (L. Fiedler, National Crop Protection Center, College, Laguna, Philippines; personal communication). When bait was placed at ground levels rather than in tree crowns (an approach that appears less effective than crown-baiting), significant increases (from a pretreatment yield of 2.9, to 5.8 during treatment) in yield were observed in the experimental plot treated for 1 year. Sultan (1978) simulated the effects of periodic baiting with rodenticides by trapping biweekly in two 1-ha coconut plots located near Calauan, Laguna, Philippines. Yields in the trapped plots averaged 6.4 for the 5 months of the study, significantly greater (paired Student's *t* test, one-sided, $t = 2.71$, $p < 0.05$) than the mean yield of 4.2 in the nontrapped reference plots. Impressive reductions in damage and concomitant increases in yield have also been reported when trees are crown-baited with anticoagulant rodenticides in South America (Valencia, 1980). Although compensation by replacement (manner *a* above) was not directly tested, the varieties of palms represented in these studies were unable to fully replace nuts that were damaged by rats.

The possibility remains that the palms in these studies were partially compensating for damaged nuts but in the second manner (*b*) hypothesized above, i.e., a manner that would not be detected by measuring yield as number of harvestable nuts without regard to the weight of the copra produced. This possibility was tested in the study reported here.

MATERIALS AND METHODS

We compared the sizes and weights of coconuts from a plot A that had been effectively treated for rat damage with the sizes and weights of coconuts from a plot B where chronic and heavy damage by rats was occurring.

In plot A, a mean of 1.2% of tiles had signs of rat activity when 25 vinyl tiles were coated with printer's ink and placed at the bases of palms for 3 nights monthly for 1 year before the study. A mean of 0.5 fallen, rat-damaged nuts were counted in monthly surveys conducted during the same period. Comparable data for plot B are available only from another study begun later; a mean of 53% of the tiles had signs of rat activity, and a mean of 29 fallen, rat-damaged nuts were counted during monthly surveys for 12 months beginning 11 months after the study described here was completed.

If the palms could adjust for damage, the mechanisms should already be functioning within Plot B, and that coconuts in this plot should be larger and weigh more than coconuts in Plot A. To assure that the postulated compensation was still not occurring in Plot A, we conducted the study after rodent damage had been effectively controlled for 21 months. Since factors other than rat damage, e.g., soil condition and fertilization, variety and age of trees, non-rodent pests, and tree spacing, obviously also influence the sizes and weights of coconuts, both plots were located within a large coconut-growing area near Victoria, Mindoro, Philippines. The plots had the same local growing conditions, the same local varieties of palms of similar ages, and were cultured (except for rodent control) and harvested in similar manners. The plots were located about 300 m apart and were separated by a road.

Sixty nuts were randomly selected from those harvested on the same day from each plot. The nuts were marked and numbered with paints to allow for individual identification. The following measurements were recorded: sizes (cm) -- greatest horizontal circumference, intact coconut and nut with husk removed; and, weights (kg) -- total, endosperm (fresh) plus milk, endosperm (fresh) alone, and dried endosperm (copra). Copra weights were obtained after the marked nuts had been dried in the farmers' oven as part of a batch. Thus, copra weights reflect the actual drying process on which the market value is based.

Frequency distributions of measurements were calculated for the samples from each plot. These were compared using one-sided Student's *t* tests (Simpson et al., 1960) because we predicted that nuts from Plot B would be larger and weigh more than nuts from Plot A. Strength of association tests (η^2; Linton et al., 1975) were conducted on significant *t* values.

RESULTS AND DISCUSSION

Coconuts from Plot A were slightly, but not significantly ($p > 0.35$), larger (total circumference) than those from Plot B (Table 1). For all other measurements, coconuts from the plot (B) suffering heavy rat damage were slightly greater than those from the plot (A) with little or no rat damage. Differences were significant for fresh weight of endosperm ($p \approx 0.05$) and for copra weight ($p < 0.005$). Fresh weight of endosperm averaged 0.87 kg per nut for samples from Plot A, a mean of 0.04 kg per nut (or 4.4%) less than for nuts from Plot B. Copra content averaged 0.37 kg per nut for samples from Plot A, also a mean of 0.04 kg per nut (or 9.8%) less than for nuts from Plot B.

The results from the Student's *t* test appeared consistent with the idea that palms with heavy damage compensated by increasing copra content of undamaged nuts. However, based on the strength of association tests, only about 0.07 (i.e., 7%) of the variance in copra weights, and only about 0.02

*Table 1. Sizes and weights of coconuts from two plots (A-B) located near Victoria, Mindoro, Philippines. Plot A had been baited in tree crowns with anticoagulant rodenticides for 21 months before sampling, had little evidence of rat damage, and had greatly increased nut production. Plot B had received no attention for rat control, and had chronic, heavy damage. Sixty harvested nuts were selected at random from each plot, then individually measured and weighed. *$\bar{x} \pm SE$ = mean ± standard error of the mean. ** π^2 = strength of association = $\frac{t^2}{t^2 + df}$, where t = Student's t, and df = degrees of freedom for t-test.*

Measurement	Plot A (little or no rat damage)		Plot B (heavy rat damage)		Student's		
	$\bar{x} \pm SE$*	Range	$\bar{x} \pm SE$*	Range	t	p	π^2**
Circumference (cm)							
Total	63.8 ±0.56	55.7 –77.0	63.5 ±0.50	55.3 –73.1	0.37	—	—
Endosperm	46.7 ±0.48	32.2 –59.0	47.3 ±0.52	38.2 –56.2	0.78	—	—
Weight (kg)							
Total	1.9 ±0.04	1.2 – 2.7	2.0 ±0.05	1.1 – 2.8	1.19	—	—
Endosperm, fresh + milk	1.3 ±0.04	0.5 – 2.0	1.4 ±0.04	0.8 – 1.8	0.29	—	—
Endosperm, fresh	0.87±0.020	0.2 – 1.2	0.91±0.023	0.6 – 1.4	1.65	≈0.05	0.02
Endosperm, dry	0.37±0.009	0.00– 0.48	0.41±0.009	0.27–0.56	3.06	<0.005	0.07

(i.e., 2%) of the variance in fresh endosperm weights, were accounted for by the major cultural differences between the plots, the presence or absence of rat damage. Thus, there was only a weak association between differences in copra and fresh endosperm weights and compensation for rat-damaged nuts.

To further test this interpretation, we compared sizes and weights of the samples from Plot B with 60 nuts from another nearby plot that had greatly reduced rat damage for 26 months. Even though these nuts were harvested and dried about one-half year after the nuts from Plot B, and although the whole nuts in this plot were smaller and weighed less ($p < 0.05$; $\pi^2 = 0.07$) than nuts from Plot B, copra and fresh endosperm weights were not significantly different (one-sided Student's *t* test, ps > 0.25 and 0.45, respectively).

We concluded that compensation for rat-damaged nuts, by increasing the copra content of undamaged nuts, played at most a minor (7% or less) part in the differences in nut weights that we observed between the experimental plots. In this respect, our results are similar to those of Williams (1974b) who was also unable to measure this type of compensation in individual palms.

In the experimental plots near Victoria, Mindoro, Philippines, we measured impressive increases in yields in response to effective rat control despite compensation by replacement that may have occurred during the pretreatment period and in the rat-damaged reference plots. Further, the lower copra weights (about 10%) of nuts from the undamaged plots were unimportant when compared with the improved yields (about 150%), and were due mostly to factors other than compensation for rat-damaged nuts. Additional studies would be useful to determine whether compensation for rat damage is an important consideration for other varieties of palms grown in other pest situations in the Philippines.

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