DEVELOPMENT AND EVALUATION OF METHODS TO REDUCE RAT DAMAGE TO COCONUT IN THE PHILIPPINES

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ABSTRACT: Based on findings from studies conducted in the Philippines over a span of almost a decade, primarily by scientists at the Philippine National Crop Protection Center, crown-baiting (wherein bait containing anticoagulant is placed monthly in the crowns of some palms in a coconut plantation), holds the potential of providing highly economical protection from rat damage. The success of the method in various field trials appeared related, in part, to selective removal of rodents that feed in the palms and to the use of baits that were preferred over growing nuts. Studies have also indicated that only 10% or less of the trees may have to be baited for effective control, although additional field trials are needed to confirm the optimal levels of treatment for different coconut-growing regions in the Philippines. Based on findings from the studies, fallen, rat-damaged nuts may represent only a small portion of the damage that rats inflict on coconut palms in the Philippines.

INTRODUCTION

Extensive coconut planting in the Philippines began in the mid-1600s with a Spanish decree that all villages plant 200 trees to provide fibers for the rigging of galleons. Later, in 1768, each family was directed to plant at least 200 ft^2 to coconuts. Major shipments of copra, initially to Europe, began in 1880. Currently, about 21% of the agricultural land in the Philippines or about 2.2 million hectares is planted to coconuts. Coconuts have become an important food item and are grown in nearly every province both on small farms or as plantation crops. Owner-operated farms average between 1 and 2 ha in different provinces (Woodroof 1979, Anon. 1975). About 70% of world copra exports and about 53% of the worldwide production of coconut oil originate in the Philippines (Woodroof 1979). The country also supplies about 78% of the U.S. market for dessicated coconut (Anon. 1975).

Despite its status as the world's leading producer of coconut, yields for Philippine palms are among the lowest of the major producing countries. The low yields have been attributed to (a) the predominance of old trees past peak productivity, (b) low-yielding native varieties, (c) poor soil, and (d) other factors. Among the other factors, rat damage is sometimes regarded as a factor that can influence coconut yields.

Only during the past decade, however, has substantive evidence been obtained implicating rat damage as an important and limiting factor for coconut yields in at least some Philippine groves. Whereas rat damage has been argued as unimportant because of the capabilities of trees in some geographic regions to compensate for rat-damaged nuts (Barbehenn 1971, Williams 1974a), such compensation was not found in Philippine coconut groves where it was investigated (Reidinger and Libay, in press). In this paper, we present a brief overview of information now available on the nature of rat damage in the Philippines, and summarize the results from a series of studies conducted over almost a decade mostly by staff at the Philippine National Crop Protection Center.

SMALL MAMMAL SPECIES

Small mammal species in Philippine coconut groves include Rattus rattus mindanensis, R. exulans, R. argentiventer, and Suncus murinus. Of these, R. argentiventer is restricted in known geographic distribution to the islands of Mindanao and Mindoro (Barbehenn et al. 1973), and S. murinus, an insectivore, is probably not a coconut pest.

In 9 studies conducted by staff of the Philippine National Crop Protection Center, R. r. mindanensis averaged about 58% of snap-trap collections at the ground level of coconut groves, whereas R. exulans averaged about 14% of the collections (Table 1). On Mindoro, 1 of the 2 islands known to be inhabited by R. argentiventer, this species accounted for about 12% of the ground-level collections. In each of these studies, R. r. mindanensis appeared to be the primary coconut pest. Its prevalence in the field both at the ground level and at the crown level (Rodent Research Center 1976), and its ability to damage nuts (Sultan 1978) leave little doubt as to its destructive potential.

DAMAGE PATTERNS

Conceivably, rats could affect coconut yields during any of the stages of nut development, from flowering to maturing nuts. To our knowledge, there has not been a systematic assessment of the stages of nut growth that are affected by rat damage, although there is reason to suspect that such an investigation is needed (Reidinger and Libay 1980). Most investigations of the patterns of rat damage have focused on maturing nuts, probably in part because damage at this stage is highly visible to the farmer, and probably in part because counts of fallen, rat-damaged nuts have traditionally served as the major criterion for assessment of damage.

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Table 1. Small mammal species trapped on the ground in Philippine coconut groves on Mindoro and Luzon Islands.[a,b]

	Species composition (%)				
	Rattus rattus mindanensis	R. exulans	R. argentiventer	Other[c]	Trap nights
			Mindoro Plots		
	49	14	17	20	300
	64	19	16	0	150
	55	22	9	15	150
	52	30	9	9	50
	71	19	10	0	50
Means	58.2	20.8	12.2	8.8	
			Luzon Plots		
	95	0	-	5	1,332
	74	3	-	23	62
	24	3	-	73	40
	38	20	-	42	1,050
Means	57.8	6.5	-	35.8	

[a]Based on Hoque (1973), Reidinger and Libay (1980), Sultan (1978), and our own unpublished data.

[b]Some totals do not equal 100% due to rounding.

[c]Mostly Suncus murinus.

Hoque (1973) collected 3,199 rat-damaged, fallen nuts in Laguna Province and examined patterns of damage. She found that 65% of the nuts were damaged at the base, 25% had suffered lateral damage, and about 10% were damaged at the distal end. Kurylas (1974) found roughly the same percentages in 4,545 nuts collected over a 1-year period in Bohol, as did Sultan (1978) for 220 nuts collected over 5 months in Laguna. This pattern of damage probably reflects the easier accessibility to rats of the basal ends where nuts are attached to the tree. No consistent pattern of damage to large (diameters greater than 16 cm), medium (between 11 and 16 cm), or small (less than 11 cm) emerged from the 3 studies; all sizes of nuts were found damaged. About one-fourth (Kurylas 1974) to one-third (Hoque 1973) of the damaged nuts sustained superficial injury to the husk, whereas the rest had holes that completely penetrated the hard shell. However, under free-choice situations in cages, R. r. mindanensis preferred button-sized nuts to maturing nuts (Sultan 1978).

Because such descriptions of damage are clearly influenced by a number of factors such as relative abundance of the different growth stages and their relative nutritional contents, palatability, tastes, and the availability of other food, only limited interpretations of this information are possible. The data serve primarily as an indication that rats are opportunistic foragers, adjusting their preferences in part according to availability of food resources.

RAT ACTIVITY AND RAT DAMAGE

A variety of methods, including snap-trapping, radio telemetry, and tracking tiles have been used to assess rat activity in coconut groves. Of these, all except tracking tiles have received only limited use. To our knowledge, Sultan (1978) provided the only report of attempts to follow movements of rats within coconut groves in the Philippines using radio telemetry. He equipped a total of 5 R. r. mindanensis and 6 R. exulans, live-trapped at the ground level, with radio transmitters and followed movements for a total of 48.2 h and 292 location changes over 1 month. Sultan (1978) also used snap traps, attached to tree trunks near the crowns, in part to monitor rat activity. In another study (Rodent Research Center 1976), bait containing tetracycline was placed in tree crowns in 1 plot and at ground level in another plot, to mark rats. By subsequently trapping rats at the crown and ground levels, and by observing the presence of tetracycline on captured rats, a measure of movement between ground and crown levels was obtained.

The tracking tile (West et al. 1976) has proven, however, to be a particularly useful tool for estimating relative rat activity in coconut plantations. In most studies (Rodent Research Center 1975, Denver Wildlife Research Center 1977, Elias 1978, Reidinger and Libay 1980), 24-50 tracking tiles/ha were placed at the bases of palms, either selected at random or systematically, for 3 consecutive nights monthly, and the number of tiles with rodent tracks was recorded. Results were reported as the 3-night average percentage of tiles that were tracked.

In 13 plots not treated for rat control, but monitored for tracking tiles for 1 to 24 months, mean indices of activity have ranged from 19 to 76% of the tiles marked. The specific relationships between rat activity in these plots and rat damage, as determined by numbers of fallen, rat-damaged nuts, has not been carefully assessed. We suspect, however, that such associations would be weak for several reasons. First, measurements of rat activity were made at ground level, whereas rat damage (in mature groves) occurs in the tree crowns. Second, some rats apparently cause more damage than others (Williams 1974b), and some rats active at ground level apparently never climb trees. Third, counts of fallen, rat-damaged nuts may represent only a small portion of damage caused by rats in the tree crowns in the Philippines (Reidinger and Libay 1980), and relationships between counts of fallen nuts and other forms of damage are currently unknown. Thus, a count of fallen, rat-damaged nuts may, in itself, represent an inadequate measure of damage-related activities of the rats.

Others have also noted that the relationship between rat activity and rat damage is not always a clear one. For example, both Hoque (1973) and Wodzicki (1969) found extensive rat damage in groves with little rat activity, based on trapping data. Sultan (1978) found that trap success was poorly related to measurements of rat activity using tracking tiles, and similar observations have been made in Philippine ricefields (West et al. 1976). Nonetheless, relative changes in percentages of marked tracking tiles have been sensitive enough to provide reliable and interpretable measures of gross impacts on rat activity within coconut groves, such as effective control practices and seasonal fluctuations due to climate or abrupt changes in adjacent croplands (Reidinger and Libay 1980, Bruggers 1979, 1980).

The most common assessment of rat damage to coconut involves the number of fallen, rat-damaged nuts. Although this practice has been incorporated into most of the studies conducted in the Philippines, actual measurements of yield (in treated and reference plots) may provide a more reliable measure of the effectiveness of a given control practice. Reidinger and Libay (1980), for example, recorded 129 fallen nuts with obvious signs of rat damage in 2 treated plots (1 ha each) during 2 years of study, 93% of which were counted during the first 2 months after treatment. In contrast, 593 fallen nuts were counted in reference plots. The difference represented only about 4.5 to 5.8% of the estimated increases in yield, based on actual accounts of nut production, due to effective rat control. Reidinger and Libay (1980) suggested that rats in the experimental plots caused far more damage than would have been recognized by measuring only damaged nuts, and suggested that actual losses to rats in the Philippines and perhaps in other countries, may be much greater than is presently realized. Results from other studies conducted in the Philippines have been consistent with this observation.

Additional studies are required to further describe the extent and nature of rat damage to coconuts; and until such information is available, it appears prudent to base economic benefits of rat control practices on actual measurements of yield, and to use measurements of fallen, rat-damaged nuts primarily as a relative index for monitoring the progress of the control approach.

Data from studies described above suggest several features of rat activity important for control. First, based on the results of radio telemetry by Sultan (1978), it appeared that R. r. mindanensis had generally larger home ranges at the ground level (mean of 963 m^2) than did R. exulans (611 m^2); no tree-climbing was recorded for either species in his study. The sizes of home ranges for these species suggest that differences might be expected in the degree to which each encounters sparsely distributed bait stations. Second, based on results from the tetracycline bait study (Rodent Research Center 1976), R. argentiventer did not move from the ground to the crown level of the coconut grove, supporting the idea that R. argentiventer is not a pest species in coconut groves even though it is sometimes present on the ground level (Table 2). In contrast, all R. r. mindanensis and R. exulans collected in the tree

Table 2. Movement of rats in coconut groves in Mindoro Oriental. Fifty bait points were established for 1 week in crowns (Plot A) or on the ground (Plot B) and stocked with rice/tetracycline bait. Subsequent snap-trapping was conducted at locations reversed from bait placement and rats were examined for evidence of bait consumption.[a]

	Rattus rattus mindanensis		R. exulans		R. argentiventer	
	Trapped (n)	Marked (%)	Trapped (n)	Marked (%)	Trapped (n)	Marked (%)
Plot A						
crown-baited, ground-trapped	43	65	13	77	11	0
Plot B						
ground-baited, crown-trapped	7	100	4	100	0	0

[a]Modified from Rodent Research Center 1976.

crowns had been previously marked by bait located at the ground level, and some of each collected at the ground level had been previously marked by bait placed at the crown level. Third, also in the study utilizing tetracycline bait, nearly twice as much bait was taken from ground stations as from those placed in trees. We interpreted these results as confirming that the population of rats feeding in tree crowns represents only a fraction of that feeding on the ground. Thus, baiting in crowns would be expected to result in more specific control of damaging animals and to require less bait material for the same degree of control.

Fourth, the studies indicated that changes in rat activity within coconut groves were sometimes influenced by changes in adjacent habitat. For example, Reidinger and Libay (1980) observed increased rat activity when nearby fields of sweet potatoes and rice were harvested. In more recent studies conducted by the first author and other scientists at the National Crop Protection Center (Bruggers 1979, 1980), increased rat activity was observed within experimental plots located in Bagabag, Nueva Vizcaya and in Calauan, Laguna, shortly after land preparation in adjacent rice or cornfields and following harvest of these fields. The lowest rat activity occurred during late vegetative and maturing stages of the adjacent rice crops. Thus, in situations where coconut groves are near other crops, the available data suggest a dynamic pattern of movement by rats between the coconut grove and adjacent croplands. Such movements need to be considered in the evaluation of potential control practices.

CONTROL METHODS

Banding

Hoque (1973) demonstrated that rat damage to coconuts could be effectively reduced by banding individual trees, by keeping the bands in good repair, and by trimming overlapping fronds. The approach has been an impractical one in many situations, in part, because many growers are reluctant or unable to pay for the high initial costs of banding materials and fail to maintain clean groves. Rubio (1980) estimated an initial annual cost in labor and materials for banding trees and trimming overlapping vegetation on 1 ha at P714 (1 Philippine peso currently equals about US $0.12), with additional maintenance costs of P366 over the 10-year life of bands. She estimated a 10-year cost:benefit ratio for banding to be 1:25. We believe several of Rubio's assumptions may be optimistic, particularly those relating to effective band life and maintenance costs for clearing vegetation in dense Philippine plantings, and that actual cost:benefit relationships for small growers would be less favorable.

Ground-Baiting

Although this technique is not uncommon in Philippine coconut-growing areas, few studies have been made to assess its effectiveness. Kurylas (1974) described the first-year results of an experimental program on 1 ha in Bohol, which was said to be replicated in other areas. The cost:benefit relationship we determined from this report was approximately 1:10, based only on differences in fallen, rat-damaged nuts recovered in treated and untreated areas.

In a study reported by the Rodent Research Center (1976), ground-baiting was conducted in a 5-ha plantation for 13 months, then crown-baiting was conducted for the next 12 months. For ground-baiting, 20 stations/ha containing 0.025% warfarin in rice shorts were checked at least twice a week and rebaited as required. Total costs, including bait, rodenticide, and labor averaged P14.50/ha/month or P8.80/ha/month during the last 6 months. Monthly crown-baiting of about 10% of the trees with 200 g of the same bait material for the first 4 months, and 100 g of the bait material for the remaining 8 months resulted in total costs of only P4.70/ha/month. During the period of treatment at ground level, a total of 443 kg of bait was used (about 6 kg/ha/month); 89.6 kg or about 1.5 kg/ha/month were used during crown-baiting. As in the Kurylas (1974) study, damaged nut fall declined slowly during ground-baiting, initially requiring 5 months to drop to 10% of initial levels, then remaining highly variable. Rat activity, determined by tracking tiles, also declined during the months of baiting but jumped to 16%, 15%, and 19% during the eighth, eleventh, and twelfth month, respectively. In contrast, numbers of fallen, rat-damaged nuts remained at or near zero after 3 months of crown-baiting. Rat activity declined to zero by the third month of crown-baiting and averaged less than 1% during the rest of the study (no tiles were marked in 7 of the 12 months when crown-baiting was used). Ground-baiting resulted in increased harvests of about 2 times the pretreatment levels and crown-baiting in harvests about 2.5 times the pretreatment levels. Since nut production by trees spanned the 2 baiting periods, counter-balanced studies would be desirable to help understand these findings. No cost:benefit relationship has been calculated for this study. Rubio (1980) estimated the cost:benefit relationship for ground-baiting to be 1:3.46, based on assumed yield increases of 100%.

Crown-Baiting

Reidinger and Libay (1980) conducted a preliminary study of crown-baiting on Mindoro over 3 years, based on reports of successful use of a similar approach in Colombia (Elias and Valencia G. 1973, Valencia G. 1980). In the trial, 100 or 200 g of 0.025% warfarin in rice shorts and/or polished rice packaged in a plastic bag was placed monthly in trees. Since rats apparently move easily from one tree to another across overlapping fronds, it appeared unnecessary to bait every tree. Baiting rate was set arbitrarily at 25% of the trees. Within 4 months, harvested nuts doubled and within 2 months, fallen, rat-damaged nuts had declined to near zero level. Results after 3 years were still extremely favorable with harvests averaging 8.36 nuts/tree/month or about 2.8 times the pretreatment level, and with an estimated cost:benefit ratio of about 1:28 (Denver Wildlife Research Center 1977). The amount of bait used, set arbitrarily in this study, averaged about 3.6 kg/plot/month (100 trees).

In Bagabag, Nueva Vizcaya, 4 plots of about 100 trees each were selected for studying baiting rates (Bruggers 1979, 1980). Each plot had at least 2 sides bordering noncoconut cropland. Baiting rates of 0.0%, 2.5%, 5.0%, and 16% of the trees were used over a 2-year period. Based on the last 18 months of the study (Table 3), even the plots with 2.5% of the trees baited had very low levels of damaged nuts, compared to the reference plot, and rat activity was less than half that of the reference plot. Increased damage occurred occasionally, but was always associated with harvesting and land preparation of adjacent riceland and never surpassed the levels found in the reference plot.

Table 3. The effect of crown-baiting rates on rat damage and activity in four plots ranging from 0% to 16% of coconut trees baited. Data are from the last 18 months of a 24-month study in Bagabag, Nueva Vizcaya.

	Baiting rate (%)			
	0.0	2.5	5.0	16.0
Rat-damaged nuts/month/ 100 trees	58.5	7.9	5.1	4.1
Rat activity/month/plot[a]	29.5	11.2	9.0	8.3

[a]Determined by 25 tracking tiles set monthly for 3 consecutive nights.

Subsequently, 3 other plots in Calauan, Laguna were selected to evaluate a 10% rate of crown-baiting (Bruggers 1980). This rate was felt to be a reasonable compromise between the higher rates originally tested by Reidinger and Libay (1980) and the lower rates, which were more sensitive to surges in rat activity when nearby crops were harvested. Again, each plot had adjacent noncoconut cropland on at least 2 sides. Two of the plots (1 and 2) were selected at random for crown-baiting of 10% of the trees, while the third (Plot 3) received no attention for rat control. Results confirmed findings of the earlier trials in that Plot 2, adjacent to pineapple, had negligible rat damage and very low rat activity throughout the 2-year study (Table 4). Rat damage and activity, far below that found in the

Table 4. Rat damage and rat activity during the last 21 months of a 2-year study comparing crown-baited plots (10% baiting rate) with a reference plot.

	Rat damage (damaged nuts/month/100 trees)	Rat activity[a] (mean monthly %)
Plot 1 (treated, adjacent to rice)	2.3	11.5
Plot 2 (treated, adjacent to pineapple)	0.1	5.4
Plot 3 (reference, adjacent to rice)	19.2	19.6

[a]Determined from 25 tracking tiles set for 3 consecutive nights each month.

reference plot (Plot 3), were also observed in Plot 1. Its higher rat damage and activity, compared to Plot 2, were attributed to the adjacent rice paddies which provided food, water, and shelter for rats during much of the rice growth, and also provided for an increased presence of rats in the grove. Probably for this reason Plot 1 did experience some surges in rat activity with related temporary increases in damage. These results indicated a potential effectiveness of 10% crown-baiting, although cost:benefit relationships have not yet been determined. Rubio (1980) estimated a cost:benefit relationship of about 1:25 for 10% crown-baiting, assuming a 133% increase in production.

DISCUSSION

Based on these results and information on rat activity, we speculate that the success of the crown-baiting method in rapidly reducing and maintaining low rat damage was related to at least 2 factors. The first involved selectively killing rats that were climbing trees and actually causing damage, thereby reducing costs for bait and minimizing impacts on nonpest species. Of interest, Sultan (1978), using snap traps (50/ha) placed alternately in tree crowns and on the ground for 3 days every 2 weeks, was able to markedly reduce damage with an estimated cost:benefit ratio of 1:4. The second factor probably involved the use of a bait (rice) that was preferred to the growing nuts, and the use of chronic rodenticides that the rats could not easily associate with sickness. Baiting rate also has an influence on the rapidity with which rat activity and damage are reduced and on how well a maintenance program performs when rats periodically reinvade from adjacent habitats. Baiting about 10% of the trees appears to be a reasonable level to deal adequately with both situations under most conditions. We conclude that the crown-baiting approach holds the potential for highly economical protection of coconuts from rat damage in the Philippines. The approach warrants additional studies on such aspects as regional efficacy and environmental hazard that are prerequisite to its recommendation for general use. It has been pointed out that a difficulty with crown-baiting relates to the mechanics of placing bait in trees. This is of particular concern in areas with tall trees in old plantings. We have, ourselves, encountered these difficulties in the course of research studies. A practical solution we have found to avoid climbing is to use a long bamboo pole (or 2 lashed together) to place bait pockets in crowns. In fact, such a system (with a curved knife blade attached to the end of the pole) is commonly used in some parts of the Philippines for harvesting coconuts.

Ground-baiting is obviously the method of choice for situations where coconuts are interplanted with ground crops that are also suffering rat damage. Although the practice is not common yet in the Philippines, it is being encouraged, particularly among small producers. Baiting rate also has an apparent impact on the success of ground-baiting. Increased density of bait points would probably help speed the slow declines in rat activity and damage found in several studies. Possibly a combination of ground-and-crown baiting, much like the trapping experiment of Sultan (1978), would help improve the efficiency of maintenance programs in intercrop situations.

Finally, although we have quoted cost:benefit ratios based on changes in nut fall or in production increases over relatively short time periods, we urge caution in interpretation. The compensatory mechanisms of palms may differ among varieties and appear to differ among various geographic areas. The substantial production increases above those estimated by damaged nut fall observed by us and others are not yet understood. It has been suggested, and there are some indications from data, that such increases are short-term responses of trees to interruption of damage to young coconuts and that production might stabilize at lower levels after several years of effective rat control.

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LITERATURE CITED

ANONYMOUS. 1975. The Philippines recommends for coconut 1975. Philippine Council for Agriculture and Resources Research, Laguna, Philippines. 63 pp.

BARBEHENN, K.R. 1971. Rodent control and the developing world. Paper read to the AAAS Conf. on Environmental Sciences and International Development, December 26-31, 1971, Philadelphia, Pennsylvania.

__________, J.P. SUMANGIL, and J.L. LIBAY. 1973. Rodents of Philippine croplands. Philippine Agriculturist 56(7&8):217-242.

BRUGGERS, R.L. (ed.) 1979. Vertebrate damage control research in agriculture. Unpublished Annual Report, Denver Wildlife Research Center, U.S. Fish and Wildlife Service and U.S. Agency for International Development. 106 pp. (mimeo).

__________. (ed.) 1980. Vertebrate damage control research in agriculture. Unpublished Annual Report, Denver Wildlife Research Center, U.S. Fish and Wildlife Service and U.S. Agency for International Development. 111 pp. (mimeo).

DENVER WILDLIFE RESEARCH CENTER. 1977. Vertebrate damage control research in agriculture. Unpublished Annual Report, U.S. Fish and Wildlife Service and U.S. Agency for International Development. 86 pp. (mimeo).

ELIAS, D.E., and D. VALENCIA G. 1973. Control de roedores en el cocotero. ICA-Informa 8(8):n.p.

______. (ed.). 1978. Vertebrate damage control research in agriculture. Unpublished Annual Report, Denver Wildlife Research Center, U.S. Fish and Wildlife Service and U.S. Agency for International Development. 129 pp. (mimeo).

GALLEGO, V.C., and R.G. ABAD. 1978. Pages 107-109 in Annual Report of the Philippine Coconut Authority, Agricultural Research Branch.

HOQUE, M.M. 1973. Notes on rodent pest affecting coconut. Philippine Agriculturist 56(7&8):280-289.

KURYLAS, H. 1974. One year of rat control in coconut plantations. Plant Protection News 3(10-11): 89-97.

REIDINGER, R.F., JR., and J.L. LIBAY. 1980. Crown-baiting in coconut trees with anticoagulant rodenticides to reduce rat damage. Pages 211-222 in Proc. Symp. on Small Mammals: Problems and Control. BIOTROP Special Publ. No. 12, Bogor, Indonesia.

____________________. In press. Effects of rat damage on size and weights of coconuts. Philippine Agriculturist.

RODENT RESEARCH CENTER. 1975. Unpublished Annual Report. Univ. Philippines at Los Banos, College, Laguna. 89 pp. (mimeo).

______________. 1976. Unpublished Annual Report. Univ. Philippines at Los Banos, College, Laguna. 100 pp. (mimeo).

RUBIO, P.P. 1980. Rat control in coconut. Technology! 2(8/80):1-12.
SULTAN, Z.M. 1978. Behavioral studies of rats in relation to coconut damage. Unpublished M.S. Thesis. Univ. Philippines at Los Banos, College, Laguna. 45 pp.
VALENCIA, G., D. 1980. Rat control in coconut palms in Colombia. Pages 110-113 in Proc. 9th Vertebr. Pest Conf., March 4-6, 1980, Fresno, California.
WEST, R.R., M.W. FALL, and E.A. BENIGNO. 1976. Comparison of snap traps and tracking tiles for obtaining population indices of Rattus rattus mindanensis in the Philippines. Philippine Agriculturist 59(9&10):379-386.
WILLIAMS, J.M. 1974a. The effect of artificial rat damage on coconut yields in Fiji. PANS 20(3): 275-282.
__________. 1974b. Rat damage to coconuts in Fiji: Part I, assessment of damage. PANS 29(4): 379-391.
WODZICKI, K. 1969. Preliminary report on damage to coconut and on the ecology of the Polynesian rat (Rattus exulans) in the Tokelau Islands. Proc. New Zealand Ecol. Soc. 16:7-12.
WOODROOF, J.G. 1979. Coconuts: production, processing, products. AVI Publishing Co., Westport, Connecticut. 307 pp.