

# Incidence of Cadang-Cadang Disease of Coconut Palm in the Philippines

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## ABSTRACT

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By a new survey method, the total number of new cases of cadang-cadang disease in the Philippines in 1978 and 1980 was estimated to be 391,000 and 209,000 trees, respectively. The decline was significant and independent of changes in the age distribution of the palms. Comparison with earlier records showed a considerable decline in incidence of the disease during the last 20 yr.

Cadang-cadang disease, which is caused by a viroid like pathogen, is lethal to coconut palm and occurs in some areas of the Philippine islands of Luzon and Samar and some neighboring smaller islands (3,6,7,9). Palms less than 10 yr old are rarely diseased, and disease incidence increases with the age of the palms (8).

Bigornia et al (4) and Price and Bigornia (5) recorded cadang-cadang incidence yearly from 1951 to 1957, in 1959, and in 1967. They observed, from a vehicle moving slowly along main roads, palms that were more than 20 yr old. They found that cadang-cadang incidence increased to a peak in 1957, when about 46% of the surveyed palms were diseased, and then decreased.

Recently, we conducted surveys to determine new cases of cadang-cadang disease in the Philippines and to determine whether incidence of the disease had changed significantly. For comparative purposes, we used the old survey method in 1976. We also introduced a new survey method because the old method did not provide information on age distribution of the palms or the stage of the disease. From interviews with farmers, we learned that palms in the medium and late stages are often removed in an attempt to control the disease. The palms bear fruit during the early stage, and symptoms are difficult to recognize.

## METHODS

**Strip survey.** In 1976, the Albay and Camarines Sur provinces were surveyed for cadang-cadang disease by the method

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of Bigornia et al (4). The surveyed roads were slightly different from those surveyed between 1951 and 1959 but were the same as those surveyed in 1967.

**Biennial survey.** One-hectare plots separated by 1 km were established along the main roads of the Camarines Norte (except in the northwestern third), Camarines Sur, Albay, Sorsogon, Catanduanes, northern Samar, and eastern Masbate provinces. In 1978 and 1980, all palms in these plots were observed from the ground for cadang-cadang symptoms, and their ages were estimated.

Palms with cadang-cadang disease were classified as follows: early stage—little if any yellowing of fronds, normal shape of fronds, normal number but abnormal size and shape of nuts; medium stage—absent or very few nuts, inflorescences with necrotic tips, yellowish green fronds with fibers remaining attached to the petioles, slightly reduced number and length of fronds; late stage—nuts absent, inflorescences absent or very small, short and yellowish fronds, only upper fronds remaining.

**Analysis.** New cases of cadang-cadang disease appearing in 1 yr in one province could not be counted directly because the surveyed palms were not marked individually. The number was estimated

by dividing the proportion of early disease stages by 2.9—the estimated number of years this stage lasts in 22-yr-old palms (11) (surveyed palms were an average of 26 and 28 yr old in 1978 and 1980, respectively)—and multiplying by the total number of palms in the province (1).

To detect significant changes in disease incidence, independent of changes in age distribution of surveyed palms and independent of the number of diseased palms removed by farmers, we excluded palms in the medium and late stages of cadang-cadang and palms less than 10 yr old from the analysis. The provinces were then divided into 7–20 areas, each containing 400–500 surveyed palms. For each area, surveyed palms were grouped by age (11–20, 21–30, 31–40, and >40 yr), and disease incidence was calculated for each group. Any of the first three age groups that contained fewer than 50 palms was combined with a neighboring age group. If the last age group contained fewer than 20 palms, it was deleted.

Disease incidence is always close to zero in palms less than 10 yr old; incidence increases nearly linearly up to age 40 and appears to be constant for older palms. Therefore, for each area, incidences in the first three age groups were used to fit a regression line originating from the point of no disease incidence in 5-yr-old palms; slope of the line was  $1/N \sum Y/x_{-5}$  ( $Y$  = percentage of early stages of cadang-cadang,  $X$  = average palm age, assumed to be 17, 27, and 37 yr for the three age groups,  $N$  = number of age groups, usually three). Because cadang-cadang disease is not randomly distributed (10), the significance of changes in the disease incidence

**Table 1.** Example of the test for the significance of changes in cadang-cadang incidence in the Philippines

Area	Regression slope for 11- to 40-yr-old palms		Percent of early disease in >40-yr-old palms		Sign test ( $P = 0.18$ )
	1978	1980	1978	1980	
1	0.082	0.038	3.8	1.1	—
2	0.052	0.088	7.9	4.1	—
3	0.050	0.000	2.5	1.1	—
4	0.183	0.054	16.8	11.8	—
5	0.117	0.010	14.9	9.4	—
6	0.232	0.231	9.8	3.4	—
7	0.171	0.051	9.3	6.8	—
8	0.216	0.328	6.2	8.6	+
9	0.141	0.033	9.5	3.9	—
10	0.005	0.006	5.3	1.4	—
11	0.000	0.009	... <sup>a</sup>	... <sup>a</sup>	+

<sup>a</sup> Deleted because fewer than 20 palms were surveyed.

between 1978 and 1980 was examined with the sign test. Areas in which the slope of the regression line increased but the incidence in palms older than 40 yr decreased, or vice versa, were deleted. An example of the analysis for Camarines Norte province is given in Table 1.

## RESULTS

**Strip survey.** In 1976 the incidence of palms (>20 yr) showing cadang-cadang symptoms was 5.2% in Albay province and 31.0% in Camarines Sur province. Figure 1 shows these results and those reported previously (4,5).

**Biennial survey.** Correlations between age of palms and percentage of cadang-cadang in areas with low (<3%), medium (3–10%), and high (>10%) disease incidence (Fig. 2) were obtained by grouping records of 217,000 palms collected during the 1978 biennial survey and during an earlier survey (Zelazny, unpublished). For palm groups up to an average age of 40 yr, the correlations were nearly linear. For palms older than 30 yr, disease incidence seemed to be independent of palm age.

From estimates of the duration of the stages of the disease (11), an early/late stages ratio of 1 or less would be expected. During the 1978 biennial survey, the early/late stages ratio ranged from 1.0 (Catanduanes province) to 7.8 (Albay province) and was 2.9 for all provinces. This indicates that in many areas, palms with advanced cadang-cadang disease are regularly removed by farmers.

Between 1978 and 1980, the incidence of early cadang-cadang disease decreased in all provinces except Sorsogon, and the overall decline was highly significant (Table 2). The decrease was independent of changes in the age distribution of the palms; in fact, most provinces showed a slight increase in the average palm age (which would have been expected to result in a slight increase in the disease incidence).

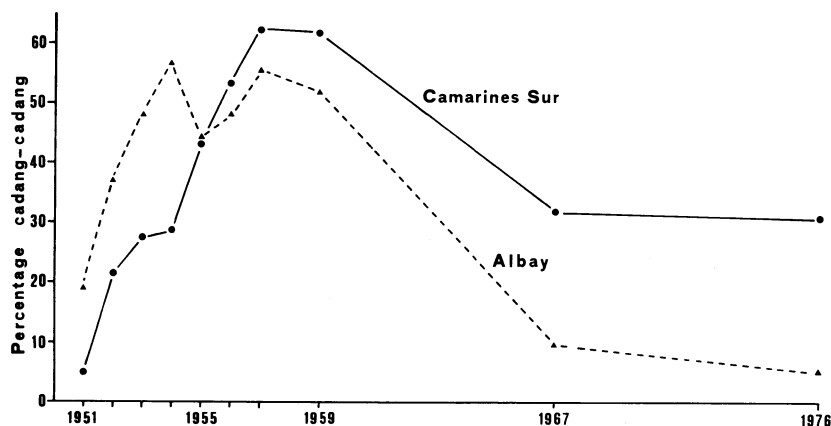
In the 1978 survey, the incidence of all cadang-cadang stages among palms older than 20 yr was 3.5% in Sorsogon province and 10.4% in Camarines Norte province. Bigornia et al (4) recorded 31.3 and 33.8%, respectively, in 1959 with the strip survey method.

## DISCUSSION

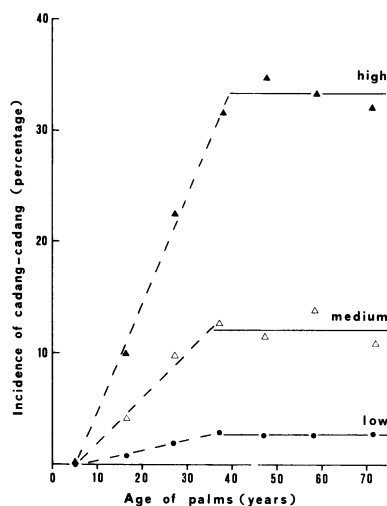
Cadang-cadang incidence has declined considerably in the Philippines during the last 20 yr and declined significantly between 1978 and 1980. Although disease incidence is low now compared with the 1952–1959 period, the combined number of new cases appearing each year is still substantial and is comparable with a planted area of 2,000–3,000 ha. Moreover, this and earlier studies showed that the distribution of the disease is highly heterogeneous. Thus, some farmers have experienced almost total loss of their

**Table 2.** Results of biennial surveys of the incidence of cadang-cadang disease in the Philippines

Province	Average age (yr) of palms		Palms in early stage of disease (%)		Estimated new cases (×1,000)		Changes in incidence
	1978	1980	1978	1980	1978	1980	
	Camarines Norte	30.2	30.9	2.45	1.44	41	
Camarines Sur	24.2	26.5	4.61	2.04	248	110	Declined ( $P = 0.004$ )
Albay	20.3	21.9	1.09	0.58	27	15	Declined ( $P = 0.022$ )
Sorsogon	27.2	29.0	0.81	0.96	21	25	None
Masbate	34.0	33.6	0.91	0.47	19	10	None
Catanduanes	23.7	24.9	2.71	2.40	13	12	None
Northern Samar	27.1	28.6	0.67	0.39	22	13	Declined ( $P = 0.032$ )
Total	26.4	28.1	1.67	1.00	391	209	Declined ( $P \leq 0.001$ )



**Fig. 1.** Percent of palms (>20 yr old) showing symptoms of cadang-cadang disease in Albay and Camarines Sur provinces. Sources: 1951 to 1959, from Bigornia et al (4); 1967, from Price and Bigornia (5); 1976, present survey.



**Fig. 2.** Percent of palms showing symptoms of cadang-cadang disease in areas with low (<3%), medium (3–10%), or high (>10%) disease incidence. Palms were grouped by estimated age (1–10, 11–20, 21–30 yr, etc), and the average age and disease incidence are given for each group. Interrupted lines are linear regressions fitted to the data for palm groups with an average age of less than 40 yr; solid lines are the average disease incidences for palm groups older than 30 yr.

plantations for the second time within 30 yr.

A rough estimate of present, total economic losses to the disease can be

obtained as follows: From other data (Zelazny, unpublished), it is estimated that coconut palms are an average of 30 yr old when they start showing cadang-cadang symptoms. Because healthy palms have to be replanted after about 60 yr, a farmer would probably have to make one additional replanting for every two new cases of cadang-cadang disease. A replanted palm is not fully productive for about 15 yr, and from the current figures on average yield (2), we can estimate that during this time the replanted palm produces 400 nuts less than a mature palm does. This is the main economic loss for the farmer; other factors such as removing diseased palms and costs of seedlings, planting, and maintenance are negligible. With a ratio of 4.5 nuts per kilogram of copra, 300,000 new cases of cadang-cadang per year cause an annual loss of 13,000 tons of copra, presently valued at \$3.5 million.

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