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Environmental Impact of Lethal Yellowing Disease of Coconut Palms

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by

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INTRODUCTION

During the past four years, urban South Florida has undergone an increasingly noticeable environmental change. City streets, parks, and beaches, that were once lined with graceful trees of Coconut (*Cocos nucifera*) and other species of palms, are now either fully exposed to the intense tropical sun or have scattered clusters of dying trees with their leaves yellowing and then characteristically hanging dead (Fig. 1). The epidemic of Lethal Yellowing disease of Coconut has now spread to all of the coastal cities to the north and south of Miami.

The rapid change in the urban environment of South Florida is similar to that seen in northeastern American cities that were hit by the Dutch Elm disease. In these cities, the American Elm (*Ulmus americana*) was the dominant street-tree that had been planted. With the rapid and almost complete elimination of the Elms, the streets became stark, and the mood of the city was quickly changed.* In Miami the streets and parks are also undergoing somewhat comparable changes in their physical and emotional atmosphere. The shading and cooling effects of the palms, their noise- and dirt-abatement qualities, and their aesthetic beauty, are now missed by city residents.

South Florida depends heavily on its tourist industry, which in turn is dependent on the tropical image of the area. The gracefully curved trunk of the Coconut Palms along a beach is perhaps the universal image of the romantic tropics—an image that is naturally exploited by South Florida. Therefore, the elimination of this factor can only be to the detriment of the economy of the region as well as to its environmental amenities.

FIG. 1. *Dying Coconut* (Cocos nucifera, C) *and Fiji Island Fan* (Pritchardia pacifica, F) *Palms along street in Miami, Florida. Photo by author, October 1973.*

LETHAL YELLOWING IN FLORIDA

On the mainland, the disease was first noticed in Coral Gables late in 1971. In the first year, 1,200 trees were killed. An estimated 20,000 trees died in the second year (McCoy, 1974*a*). By 1975 more than 100,000 Coconut Palms had been affected by Lethal Yellowing disease, which proceeded unchecked into all of Florida's main Coconut areas (Purdy, 1974, 1975). In addition, a huge but unknown number of palms of other species died in a similar way. Most of the estimated 500,000 Coconut Palms in South Florida are the 'Jamaican Tall' variety which is highly susceptible to the disease. In many areas of Miami and Coral Gables, Coconut Palms have now been completely eliminated.

The first symptoms that appear on a diseased Coconut Palm are premature fruit-fall and the death and discoloration of the flower-stalks. Later, yellowing begins in the lower leaves and progresses upwards into

* Lest it be thought that the other side of the Atlantic has escaped this environment-changing scourge, we must regretfully note that the towering Elms (*Ulmus procera*, etc.) around the famous playing-fields of Eton are suffering grievously and in many cases having to be removed—likewise in London's Hyde Park and very widely in the beautiful English countryside which owes so much to their presence. In some places only isolated individuals remain, being apparently too far from a source of infection for the weakly-flying insect vector of the devastating parasitic Fungus to reach.—Ed.

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FIG. 2. *Dead Coconut Palms on a plantation in Jamaica. The plot of lower palms on the right appears to be far less susceptible. By courtesy of Coconut Industry Board, Jamaica.*

the leaf-crown in from one to two months. Then the massive crown topples from the tree, leaving only the dead stump (Figs 1 and 2).

The original infection in Florida was first recorded in 1955 in Key West, which is isolated from Miami by over 150 miles (240 km) and lies at the western end of a chain of islands, the Florida Keys. By the time the disease disappeared in the late 1960s, it had killed about 15,000 trees or about 75% of the estimated original Coconut Palm population of Key West. It reappeared 100 miles (160 km) to the east-north-east at Key Largo near the mainland in 1969 and was first observed on mainland Florida in 1971 as indicated above. It then spread rapidly, until today it is present on both sides of the Florida peninsula (Fig. 3).

FIGHT AGAINST THE DISEASE

In a fruitless effort to limit the spread of the disease, the Florida Division of Plant Industry began a programme of removal and destruction of diseased Coconut trees shortly after the initial discovery. By January 1974, more than 10,000 trees had been cut and destroyed (Purdy, 1974) at a cost of about $40.00 per tree. The State placed a quarantine on Coconut and other affected palms originating from any of the infected counties. Citizen concern increased in proportion to the rapid spread of the epidemic. The Palm Society and the Save-the-Palms Committee pressed for governmental action (Popenoe & Fisher 1974). A research programme was set up at the University of Florida Agricultural Research Center at Fort Lauderdale. Fairchild Tropical Garden held an international Lethal Yellowing Research Symposium in September 1973 (Fisher, 1973). This first meeting of investigators working either with the disease or with palms was sponsored by the Tourist Development Authority, who appreciated the potential impact of a palmless Miami Beach on the tourist trade. One result of this meeting was the establishment of the 'International Council on Lethal Yellowing Disease' which will be responsible for international collaboration in research. In the meantime, research at Fort Lauderdale and in Jamaica had demonstrated remission of disease symptoms after treatment with oxytetracycline (McCoy, 1972; Hunt *et al.*, 1974).

After the feasibility of antibiotic treatment of palm trees had been established (McCoy, 1974*b*) and the

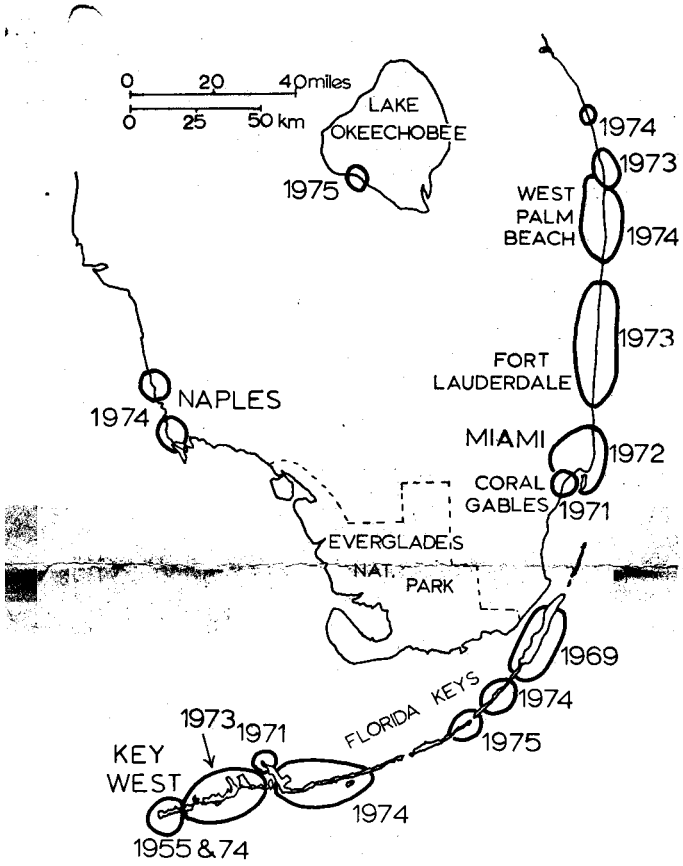

FIG. 3. *Southern tip of Florida, showing progression of Lethal Yellowing disease. Dates indicate year of initial observation and include 1969 for Key Largo near the Mainland.*

U. S. Environmental Protection Agency had given its necessary approval, oxytetracycline was made available to homeowners. The Florida Division of Plant Industry has subsidized and distributed the antibiotic to local governmental and non-profit agencies for widespread preventive and therapeutic treatment of uninfected trees and those showing only early symptoms. In the first three months of 1975, Florida state personnel injected 4,479 trees with the antibiotic (1 g/tree/injection). During the same period, 12,000 palms were treated around Naples, Florida (Fig. 3), by local agencies (Gwin, 1975). To date, the Division of Plant Industry has distributed or used approximately 1,000 kg of oxytetracycline for such injection, not including the use of it by private individuals.

Because the disease is presumably spread by an insect vector, widespread use of insecticide has been urged. However, the State of Florida has clearly eliminated any massive use of insecticides as a disease control measure because of the environmental damage that obviously might result. Yet both the University of Florida and local horticulturists feel that antibiotic treatment will never be a permanent solution of the Lethal Yellowing problem. The programme will only give more time for resistant palms to grow. They have recommended planting resistant Coconut varieties and other species as the only way to combat Lethal Yellowing (Popenoe, 1975; Purdy, 1975). In Jamaica, where Coconuts are not primarily ornamentals, antibiotic treatment has not been worth while economically because of the cost of application relative to the net annual profit per tree. In addition, the nuts are used for edible purposes—a factor not considered in Florida or by the Environmental Protection Agency when giving their approval.

LETHAL YELLOWING IN JAMAICA AND ELSEWHERE

Although Lethal Yellowing has only recently affected Florida, it has been known since 1891, when it was first reported from Jamaica. It slowly spread on that island, until the commercial Coconut plantations were affected in the early 1960s. By the end of 1974, approximately half of the 4.3 million Coconut Palms that had been estimated in 1962 had died, mainly from Lethal Yellowing. About 80% of the Jamaican Coconut areas are affected by Lethal Yellowing (D. H. Romney, pers. commun.). The first research on the disease began and continues today at the Coconut Industry Board under joint sponsorship of the local copra industry, the FAO of the United Nations, and the Overseas Development Authority of the U. K. Their major contribution has been the screening of Coconut varieties and hybrids in order to find resistance to the disease. They found that the 'Malayan Dwarf' is about 96% resistant. Recently, a superior hybrid between 'Malayan Dwarf' and 'Panama Tall' has been developed, the 'Maypan' (Harries & Romney, 1974). This new hybrid may be even better suited to Florida conditions than the 'Malayan Dwarf' which is now being used in replacing the susceptible 'Jamaican Tall'.

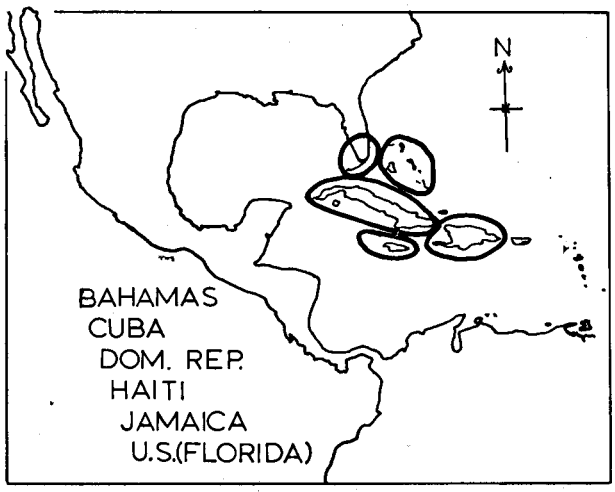

FIG. 4. *Distribution of Lethal Yellowing in the area of the Caribbean Sea. The counties listed have verified Lethal Yellowing disease.*

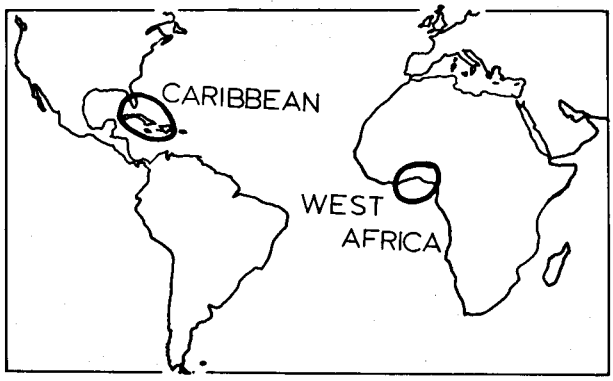

FIG. 5. *Present world distribution of Lethal Yellowing disease so far as known.*

The present reported geographical distribution of the disease is centered in the Caribbean (Fig. 4). Previous reports of Lethal Yellowing in Venezuela have turned out to be erroneous (G. H. Gwin, pers. commun.). A similar yellowing disease of Coconuts is present in the Cameroons, Ghana, Nigeria, and Togo (Fig. 5), and *appears* to be Lethal Yellowing (*see* L. Chiarappa *in* Fisher, 1973; refs. *in* Parthasarathy, 1974; cf. Heinze *et al.*, 1972; Giannotti *et al.*, 1975). Although all present evidence points to the co-identity of these two diseases, conclusive proof is still not forthcoming.

PRESENT STATE OF KNOWLEDGE

Evidence from antibiotic experiments and electron microscopic studies indicate that Lethal Yellowing is caused by a mycoplasma-like organism, MLO (Fisher, 1973; Parthasarathy, 1974; Thomas, 1974). These plant pathogens are a recently discovered group that are classified between the Bacteria and viruses (Davis & Whitcomb, 1971). The MLO are found in the young food-conducting cells, the sieve elements of the phloem (Fig. 6). Unfortunately, the actual mechanism of killing and the identity of the vector are still not known. Nor has there been any success in isolation of the causal agent or artificial transmission of the disease. The research proceeds slowly because of the slow growth and size of the palms, the innate problems of the disease (such as a long incubation period, cf. Heinze *et al.*, 1972), and the limited number of workers attacking the problem.

There are currently 14 species of palms, in addition to the Coconut, that are suspected as being susceptible (Table I). These are species which have shown symptoms of Lethal Yellowing in areas of Coconut infection and were also found to contain MLOs which are absent from healthy palms. The list may well grow, as a major test of resistance is now in progress. The world's largest palm collection of over 500 species in the Fairchild Tropical Garden is now in the Lethal Yellowing area. Among the species listed in Table I are some of South Florida's most beautiful and widely planted palms. However, none of Florida's native palm species is yet affected, and so there seems to be no threat to the palms in Everglades National Park (Fig. 3).

TABLE I

Palms Considered Susceptible to Lethal Yellowing Disease and in Which Mycoplasma-like Organisms, MLO, have been Found. (Data by courtesy of Dr D. L. Thomas, Agricultural Research Center, Fort Lauderdale, Florida.)

Arikuryroba schizophylla (Mart.) Bailey	Arikury Palm
Borassus flabellifer L.	Palmyra Palm
Caryota mitis Lour.	Fishtail Palm
Chrysalidocarpus cabadae Moore	Cabada Palm
Cocos nucifera L.	Coconut Palm
Corypha elata Roxb.	Buri Palm
Dictyosperma album (Bory) Wendl. & Drude	Princess Palm
Mascarena verschaffeltii (Wendl.) Bailey	Spindle Palm
Phoenix canariensis Hort. ex Chab.	Canary Island Date Palm
Phoenix dactylifera L. (a possible hybrid?)	Commercial Date Palm
Phoenix reclinata Jacq.	Senegal Date Palm
Pritchardia pacifica Seem. & Wendl.	Fiji Island Fan Palm
Pritchardia thurstonii Muell. & Drude	
Trachycarpus fortunei (Hook.) Wendl.	Windmill Palm
Veitchia merrilli (Becc.) Moore	Adonidia, Manila, or Christmas Palm

URBAN *versus* RURAL IMPACT

The impact of Lethal Yellowing in Florida has been on the environmental quality of city life and of recreation areas. Economic loss has resulted from the cost of tree removal and the high price of Coconut Palms used for landscaping—an estimated $75.00 per palm with a visible trunk. The long-term effect on the tourist industry can only be guessed, but fortunately

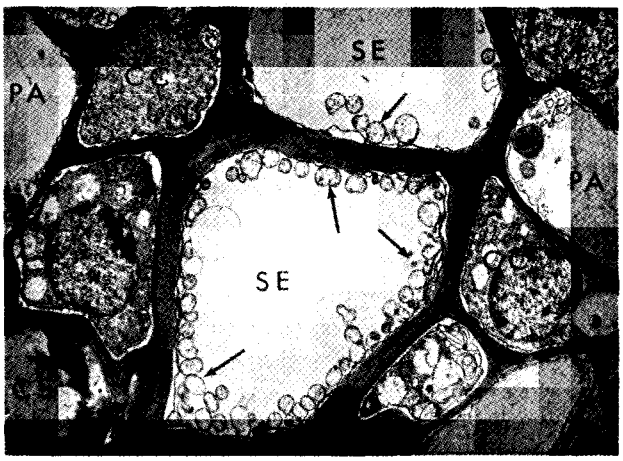

FIG. 6. *Mycoplasma-like organisms (indicated by arrows) within the food-conducting elements (SE = sieve elements of phloem) of Coconut Palm, CC = companion cell, PA = Parenchyma cell, CS = crushed sieve element. From Parthasarathy (1974, Fig. 3).*

ere is no serious loss of economic products of palms in this urban community.

On the other hand, the Coconut and other palms, especially the Palmyra and Date Palms (*see* Table I), are a basic economic resource elsewhere as either an industry (copra) or a farmyard source of food, oil, fibre, and wood. About three-fifths of Jamaican Coconut Palms are involved in copra production, which encompasses about 9,000 farmers (D. H. Romney, pers. commun.). Palms are also prime crops in West Africa, India, Sri Lanka, South-east Asia, and Oceania. In all tropical lands, the Coconut is fundamental to subsistance farming. If Lethal Yellowing should be carried far beyond its present limits of the Caribbean and West Africa (Fig. 5), there would be considerable potential for an environmental and human catastrophe of major or even overwhelming proportions being added to the world's growing tally of 'conceivable ecodisasters'. For in addition, palms widely constitute an important component of natural tropical ecosystems (Moore, 1973). They are often dominant trees in drier areas, understorey trees in wet tropical forests, and important contributors to dense coastal mangroves (e.g. *Nypa fruticans* in South-east Asia).

The potential for disaster has been felt in many quarters. The State of Florida has quarantined movement of susceptible palms in its southern counties. The States of California and Hawaii have refused entrance of palms from Florida in an effort to avoid infecting their local palms. Although there is no direct evidence of seed transmission, the Palm Society and Fairchild Tropical Garden have limited their world-wide palm-seed exchange programmes, so that seeds collected from infected areas are not sent to uninfected regions. These two private organizations have imposed their own restrictions in an attempt to eliminate the possibility of the spread of Lethal Yellowing outside its present range.

The palm-growing countries of the tropics and subtropics must become more aware than at present of the potential danger from accidental introduction of Lethal Yellowing. Agricultural and horticultural regulatory agencies would be well advised to control the introduction of possible carriers in the form of living palm specimens, being mindful of the fact that 15 species are now affected. Palm-growing countries lying adjacent to infected areas would be wise to begin introducing seeds of resistant varieties of Coconut Palms for replanting well in advance of probable Lethal Yellowing infection.

ACKNOWLEDGEMENTS

Mr George H. Gwin (Florida Division of Plant Industry), Dr D. L. Thomas (University of Florida Agricultural Research Center, Fort Lauderdale), and Mr D. H. Romney (Coconut Industry Board, Jamaica), generously made available their latest information on Lethal Yellowing. Mr Gwin and Dr Thomas kindly reviewed the original manuscript.

SUMMARY

Lethal Yellowing disease has been devastating Coconut, and presumably 14 other species of palms (including Palmyra and Date Palms), in mainland Florida since 1971. The urban environment has changed rapidly with the death of palm trees along streets, parks, and beaches. The disease is now present around the Caribbean Sea and presumably in West Africa.

Widespread injections of oxytetracycline into both diseased and healthy palms are now being carried out in Florida in an effort to control the disease temporarily. The vector has not yet been identified. 'Malayan Dwarf' variety and the newly developed 'Maypan' hybrid are resistant to the disease and are being used to replace more susceptible varieties.

The potential for environmental and economic disaster from the introduction of the disease to unaffected tropical countries, and the need for controlling its spread, are emphasized.

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Rabies and Britain's Dog Population

There are believed to be about six million dogs in Britain. A dog-owner is supposed to buy a licence to keep a dog, the cost of which is 37½ p. a year. This odd-looking fraction of currency (about 75 cents in U.S. money) is the equivalent of seven shillings and six pence (7s/6d) in pre-decimalization money. As I also pointed out recently in *The Times* (11 September 1975), the cost of a dog licence has remained unchanged for many, many years—which is curious in a country where the government takes every opportunity of putting up the price of public services.

British dogs consume nearly a million tons of meat (much of it packaged in cans) each year, and, judged by the extravagant television commercials and other advertisements, this food is wholesome and nutritious. Dogs foul the streets and carry diseases; they are a hazard to people and to traffic, and sometimes bite and even kill small children. Various restrictions on them (spelt out on the licence form) are largely ignored by dog owners. Indeed it must be assumed that the low cost of the licence cannot begin to pay for cleaning dog-filth off the streets and probably does not even pay for the administration of the licensing scheme.

Rabies is on the increase in Europe and may be expected among British dogs in the near future. The disease is a killer—a nasty, painful killer—and, when once established, is apt to be transmitted to people. On the back of the dog licence there is a warning about rabies, which reads, 'An infected dog may try to hide, froth at the mouth and tear up cloth, mats, wood, etc. It may trot for long distances, snapping at other animals, persons or objects in its path. A dog which has a wild and neglected appearance or which behaves unnaturally should be avoided. Rabid dogs will not usually attack persons who leave them alone.' All of this is accurate, except that one essential piece of information is missing: a rabid dog may also appear friendly and unafraid of strangers. In Britain, perhaps more than in most countries, people tend to respond positively to an apparently friendly dog, and this behaviour could, I believe, be a critical factor in the transmission of rabies—should the disease become established.

The truth is that Britain is unprepared to accept the possibility that rabies will occur among its dogs. There are, of course, severe restrictions on the importation of dogs and similar animals from abroad, and penalties for people who try to evade these restrictions; but it is necessary for only one infected dog to enter the country for the disease to become established. The large number of dogs, and the attitude of most people towards them, greatly increases the possibility of rabies spreading rapidly—with disastrous consequences.

What can be done? I assume that the low cost of the licence is an example of an administrative oversight—virtually everything else has gone up in price, including the cost of getting married, being registered at birth and death, and, of course, everyday activities such as posting a letter. A dog-licence fee of £5 would bring in some £30 million a year. A substantial proportion of this could be spent on cleaning the streets of dog-filth. Such a fee might also result in a reduction of the dog population and the elimination of 'unwanted' dogs, which, in turn, would lead to a saving of valuable protein-rich food. If, by putting up the licence fee, the dog population was reduced to three millions, there would be far less chance of rabies becoming established. Not only would there be fewer dogs, but only people who really wanted one would pay for the necessary licence.

Perhaps £5 is not enough. Perhaps by making the fee £10 it could be arranged for every dog to be vaccinated against rabies. A special metal tag certifying that the dog has been vaccinated could be provided by the authorities. The tag could then be attached to the dog's collar and all dogs without one destroyed—a requirement that already exists in some countries where rabies occurs.

As things stand at present, both dogs and people would be extremely vulnerable if rabies should become established in Britain. Now is the time to do something; what I have suggested could be a start—with social, economic, and medical, benefits.

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ESSAY COMPETITION

Recently, at a dinner party at its headquarters, the Poet Laureate of the Foundation for Environmental Conservation (now established legally as a non-profit, tax-exempt outfit of global scope of operation but supervised by the Swiss Federal Government Department of the Interior and the Council of State of the Republic and Canton of Geneva) contributed a memorable poem of which the first line was:

THERE IS NO GIFT MORE PRECIOUS THAN THE GIFT OF TIME

We hereby announce a competition for the best essay on the *environmental implications* of this meaningful theme: the limit of length will he 7,000 words (with due spatial allowance for any illustrations), the deadline for submission of typescripts (in quintuplicate on airmail paper) will be 1 December 1976, and the prize for the best essay with the most practical suggestions (subject to expert refereeing) will be publication as soon as possible in our Journal and 500 free reprints in special covers (or 1,000 if the judges are unanimous in commending the winning essay as of special distinction). Conformity with our Instructions for Authors would be welcome.