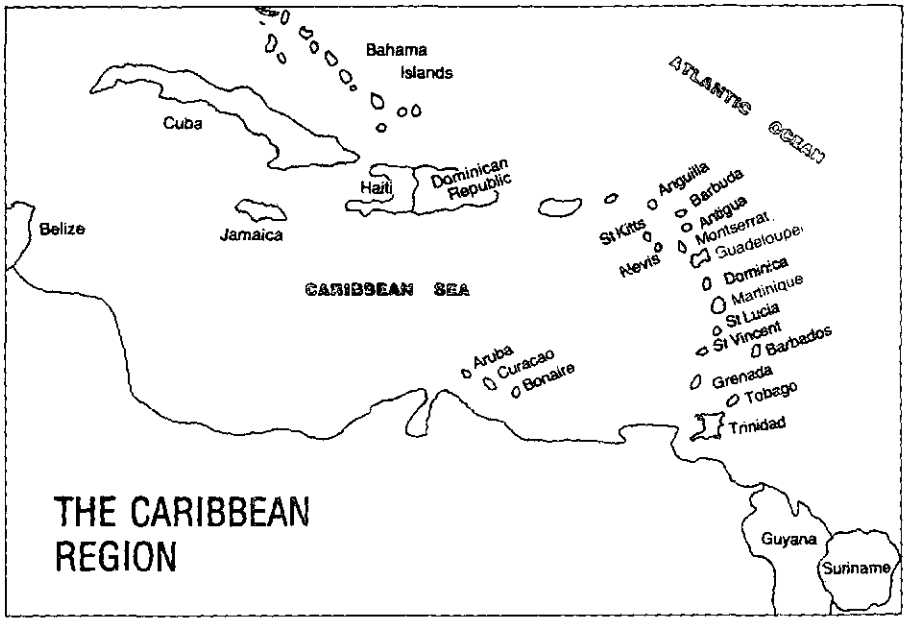
CARIBBEAN DEVELOPMENT AND CO-OPERATION COMMITTEE



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CARIBBEAN DEVELOPMENT AND CO-OPERATION COMMITTEE

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Workshop on Agricultural Research Policy and Management in the Caribbean
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RED RING RESEARCH 1956 - 1983

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ECONOMIC COMMISSION FOR LATIN AMERICA Office for the Caribbean

WORKSHOP ON AGRICULTURAL RESEARCH POLICY

AND MANAGEMENT IN THE CARIBBEAN

SEPTEMBER 26 - 30, 1983

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RED RING RESEARCH

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A CONCEPT FOR THE MAJOR PESTS AND DISEASES OF LATIN AMERICA

There was a suggestion that the coconut palm, Cocos nucifera L., might have originated from the feather palms at the northern end of the Andes or along the western coast of Central America. It was believed, with a high degree of certainty, that there were coconut palms on the west coast of Panama for some years before Colombus, however, at that time, there were no coconuts along the shores of the Atlantic in either America or Africa. The generally favored opinion now is that the coconut palm originated in south-east Asia or Micronesia, where it was noted that the palm and its products were inextricably inter-woven with the life and customs of the people to the extent that human life, in some cases, would have been impossible without it. Thus, it would appear (FigureI) that the palm dispersed westward to India and Ceylon and thence to the coast of East Africa and later eastwardly across the Pacific towards Panama. Consequently, as has been observed, the shores of the Atlantic and Latin America represent the more recent areas of coconut domination sometime after Colombus.

The palm does not have to grow near the sea since it is not halophytic, but the structure and physiology of the coconut palm make the beaches and coastal lands admirably suited to its growth. The palm requires an equable climate with high humidity and the absence of drying winds - such conditions are often found near the tropical coast-line. This limits successful cultivation of the palm to within the parallels of the Tropic of Cancer and Capricorn and an altitude of 350 metres. Within these boundaries temperature of 28^{o} - $35^{o}C$ exist and a minimum rainfall of 150 cm will generally be had.

The Latin American areas where coconuts are grown in plantations comprise the following: The West Indies, with Cuba, Haiti and Puerto Rico; Central America and South America in the tropics. The majority of these countries owe their gratitude to Spanish colonization for coconut introduction. In this zone the palm flourishes with its pests and diseases and beneficial organisms.

Concept of the Agroecosystem

The practical concept of the coconut plantation which I want to convey is not one in which palm trees stand defenselessly to be depredated by numerous organisms which bombard and assault them at random, but rather one in which the palm tree represents a form of life which must also function by reproducing more of its kind and maintaining its species in the hostile environment. Also, the palm tree functions in its own position in the biotic environment.

It has its support from its own ecological niche as do all the other forms of life in that environment, and each organism relates directly or indirectly to the palm from the level of the other available niches.

There is, in fact, therefore a natural series of functioning levels in one of which the palm tree can be consumed as food directly by one or several species of animals or plants, but not all at random. Since this concept of the available niche applies to the activities of all species in the community and the number of niches or different levels of activity for the maintenance of the plantation is finite, the numbers of individuals of the entire community will, in fact, be limited. The control of the total number of such individuals is then a function of the entire system. Briefly, it is the resultant of processes, some tending to build up or maintain the status quo of the system and others tending to destroy any existing situation. Any present situation therefore is a momentary net result.

This dynamic process or interplay of living organisms comprises the ecosystem. The direction of this process as far as the coconut plantation is concerned, may be viewed in various grades of resultants either in the direction of building up - i.e. prolific production or increasing yielddor, breaking down:i.e. declining yield, to destruction of the entire estate. The management of a coconut estate represents, in fact, the management of an ecosystem geared towards the production of coconut. Such a system which is artificially aided and directed to produce a crop is specifically regarded as an agroecosystem.

This situation is nothing new. The annals of biology have always discussed the common observation of a climax community in a self-regulating system. When a pest or disease completely overruns a coconut plantation, a new regulating force has come into being, removing the palm from its permanent niche. Any system of pest and disease management attempts to prevent this.

Diseases in the Ecosystem

I have mentioned the coconut palm as a source of food to other organisms but the tree is available only as it can interact with other components of the environment. For example, the tree belongs to a physical environment, which, by its natural physical and chemical character, precludes certain organisms and encourages others. I will like to look at microorganisms first and perhaps now I should introduce the topic of disease as I would like it to be noted. Very often, the term disease is confused with the term pathogen but disease is a pathological process, not an organism. In other words, it is a malfunctioning process caused by continuous irrigation. The pathogen is the irritant which keeps the malfunctioning process going. Thus, the same pathogen or causal organism is always associated with the disease (Koch's Postulates) wherever it is found.

It should be clear that in this exercise we will be confining our discussions to biotic pathogens which may be either plants (bacteria, fungi or seed-plants) or animals (protozoans, nematodes, mites or insects) and viruses or microplasma-like bodies.

In nature many plants are immune from the attacks of the majority of pathogens, there being restrictions of the organisms to a definite range of susceptible plants. Still, plants also vary in their susceptibility to these pathogens, and this variation depends upon the genetic makeupof both plant and pathogen. There are also variations in disease producing potential (virulence) among biotic pathogens which is determined in part by genic and cytoplasmic inheritance and in part by environmental influence.

The above statement emphasises, to some extent, the general relationship between plant pathogens and plants denoting mainly degrees of affinity - ranging from poorly specialized faculative saprophytism to highly obligate parasitism. For in its life-cycle a pathogen is either in vital association with the living plant tissues or in a state of saprogenesis. I should like to emphasize here that it is this relationship of the pathogen to the plant which induces the process or the series of processes of injurious physiological activity within the plant at the cellular level as observable disease.

All living organisms which are responsible for diseases in plants associate themselves internally with their suscepts primarily to obtain food, shelter, support or some advantage in the struggle for their existence.

The disease which results is a by-product from poor accommodation or incidental consequence of the primary purpose of the association. Nutrition is the objective in the vast majority of cases. The pathogen seeks a niche in which to obtain food for its growth and reproduction. In the ecosystem, however, the pathological processes in the palm are functional; as with this, another niche involving other species of organisms begins a relay and the existence and propagation of other species is possible as energy is being transferred from one level to another. Thus, the specificity of various pathogens must prevail as would be expected in the overall ordered system of energy transfer.

Evidently, therefore, a particular pathogen for a certain weed or intercropped plant in the coconut estate may function at a different niche from a pathogen for the coconut palm. There now comes the question of a mutual pathogen for an intercropped plant which functions in the environment of a pure stand of this plant and also is known to produce disease in the coconut palm. An example is the case of the fungus, Phythophthora palmivora causing black-pod of cocoa and bud-rot of coconuts. In intercropping systems of coconut and cocoa, the fact that different strains of the pathogen might be involved, the organism may only function at one niche if the environment allows for its pathogenicity of only one of the species - either cocoa or coconuts. This can be so if conditions for infection are not identical for both plants, and only the one optimum condition prevails.

Pests in the Ecosystem

Some organisms injure plants but do not set up pathic processes which result in continuous irritation at the cellular level. Injury might be considered only as transient irritation. At this point I would entertain the difference between the damage due to a pest as injury and that of a pathogen as disease. One must, of course, establish the generality that pests are normally associated with the fauna species of the ecosystem; although there are, of course, diseases induced by mites and insects. All the fauna species in the ecosystem are not all pests of the coconut palm. The presence of many species in the estate emphasises the levels of existence from the point of view of niches and what each species might be doing in support of the total process of the growth of the ecosystem.

The pest occupies that available niche in the system of breaking down where it relates directly to the coconut palm. Its level is supported and buffered by all the other associated niches in the ecosystem. It may be useful now to examine an example of a disease and an associated pest to illustrate the workings of the agroecosystem in plantation crops.

Red Ring Disease

Red ring disease is a serious disease to which severe losses in coconut plantations throughout Tropical America have been attributed. In Trinidad the disease was first reported in 1905. Since then the disease has been reported from Tobago, Grenada, and St. Vincent in the West Indies; and from Brazil, Costa Rica, Colombia, Ecuador, El Salvador, Honduras, Panama, Mexico and Venezuela. The causal organism is the nematode Rhadinaphelenchus cocophilus (Cobb 1919) Goodey (1960). This nematode is also apparently associated with little leaf disease in Surinam (Van Hoff and Seinhorst, 1962). The vector of this nematode is the palm weevil, Rhynchophorus palmarum L.

The larvae of the palm weevil often die when they develop in a tree which is attacked by bud-rot subsequent to the contracting of red ring disease. Thus the supression of the palm weevils, was relieved by legislation against 'bud-rot' disease when such diseased trees were destroyed. Natural cannibalism in larvae of the palm weevil resulting from over-crowding often affects the number of emerging weevils. It is known that the bacterium Micrococcus (agilis) roseus (Ali-Cohen) in Cedros wilt disease palms produces disease in affected palm weevils. Some ground lizards also feed on the adult insects. The red ring nematode dies in the decomposing tissue of the diseased tree.

Hagley (1936) reported that the heaviest losses due to red ring disease occurred at the end of the wet season and in the first 2-3 months of the dry season i.e., between December and March. The abundance of disease may sometimes depend on other insects which the palm weevil often follows. These wound the tree first, fermentation takes place, and the palm weevil is attracted to the wound in which to oviposit, Further the age of the diseased palm is important since palm weevil larvae may hardly obtain nematodes from old trees. These, therefore, limit the survival of the nematodes and break the relationship between the vector and pathogen.

With all these constraints and others to be seen later the environment itself is capable of limiting the spread of the disease; thus, conversely conditions in the environment must be right for an epidemic to begin. This may not be an easy process for some diseases. We will observe this with regard to Cedros wilt disease.

The palm weevil on the other hand, is a pest in its own right and may relate to the environment differently. Perhaps some general principles established by other authors (Bey-Bienko, 1961; Grigoreva, 1960) concerning the formation of a pest fauna might be useful introduction to the understanding of coconut pests as they exist in a somewhat stable environment.

First, there are generally more species of insects in virgin land than in a similar cultivated area of a new crop. Secondly, the density of population of the species is greater in the cultivated area than in the virgin land. Thirdly, the number of dominant and constant species in the cultivated area represents almost the total population whereas the number of dominant forms comprise only about half the fauna in the virgin land. Finally, the dominant species in the cultivated area become important pests.

One important corollary to these observations is the principle expressed by Bowden (1954) that the pests of the cultivated crop that are native to other plants in the area must be regarded as part and parcel of the fauna of the area and not only as that of the cultivated crop. The international distribution of the coconut pests shows the extent to which they are interch_ngeable in the coconut agroecosystems throughout the world. The palm weevil, Rhyncophorus palmarum L., for example, is a pest of the coconut palm, the palmiste palm, the gru-gru palm and several others. Except coconuts, the other palms are wild in the forest and in other uncultivated areas of Latin America. One may say that such wild areas represent reservoirs; nevertheless, such reservoirs may become the only source of migrant insects as the migratory locust (Locusta migratoria).

In many Latin American countries there exists differing percentages of attack from red ring disease mainly and palm weevil attack without red ring disease. In Ecuador, the palm weevil is a pest of major intensity and the adult insects attack healthy trees of any age. Adults develop in spathes, petioles and even at the bases of old trees. In other countries such intense attacks without much red ring disease are quite rare. But here the insect is a pest in a habitat consisting of several other kinds of food source.

The Distribution of Pests in the Agroecosystem

The distribution of the genus Rhynchophorus is tropicopolitan. Some species of the genus are present wherever coconuts are grown. R. papuanas in the South East Asia – New Guinea complex; R. ferrugineus and R. Schach in Sumatra, Malay-Peninsula etc., and R. palmarum, isolated to the American tropics and associated with R. cocophilus; of various species of the same genera, especially when members of different species resemble very closely as is the case with R. ferrugineus, R. schach and R. papuanas, indicates the extent of the isolating mechanisms creating by the various agroecosystems of different regions; and can explain how a disease might be isolated to an entire region if fertile vectors are absent.

However, a few of these pests have attained world wide distribution. These tropicopolitan pests have a *Coefficient of Distribution of almost 1 i.e. 100%. Out of a 100 insect pest species sampled, 4 Coccids - Aspidotus destructor, Chrysomphalus ficus, Ischnaspis longirostris and Eucalymatus tesselatus and one Scolytid beetle, Xyleborus perforans. At the other extreme, some species are quite isolated. There are 24 such species with a Coefficient of Distribution of less than 0.22%.

In general the most frequent coefficients in the population of major pests do not go beyond 0.1%. These together represent together about 60% of the pest species on the coconut growing world. 15% or so of the population have a higher coefficient and so are more distributed. The survival of each pest in a new ecosystem depends on the new species finding an available niche and the ultimate question will be, Can all of the 100 sampled pests exist together in one ecosystem?

New Guinea has 34% of the pest species sampled, Malaya has 31% and India has 25%. More notable though 1/5 of the number of the coconut growing countries have between 7% and 12%; 1/6 of the number of countries have only 6%. The overall average for all countries being about 10% of the international pests. This includes Latin American countries.

The term 'interchangeable' pests have been applied to such pests which may fit into niches in different parts of the Latin American region, such are: Brassolis sophorae L., (Lepidoptera) Castnia daedalus Cram., and C. Licus Drury (Lepidoptera) Rhinostomus barbirostis F., (Coleoptera) Metamasius hemipterus L. (Coleopters). Strategus alocus L. S. anachoreta L. S. titanus L. Potentially all coconut pests are interchangeable if niches are available in different locations. However, these mentioned above, apart from the cosmopolitan species, are present at different levels throughout Latin America. Their levels of fluctuations will depend upon the individual character of the agroecosystem and the input of human management.

$$\text{*Coefficient of Distribution} = \frac{\text{No of locations present}}{\text{Total No. of locations possible}}$$

Wilt disease of Coconuts in Latin America

Coconut diseases may be classified as those affecting the bud, leaves, stem and roots; and those which are systemic: like the wilts that may eventually cause symptoms to appear on all plant organs. Pathological wilting is often denoted by symptoms of a derangement of water-balance caused by pathological agencies. Eventually, the plant loses vitality and dies. Many fatal diseases of the coconut palm usually involve, and generally terminate with the rotting of the bud. Often the rotting of the bud may be a secondary feature only and not a primary part of the disease syndrome.

I want to emphasise the death of the bud as a visible symptom in many fatal wilt diseases of the coconut palm. This occurs, for example, in Lethal Yellowing of Jamaica, Guam disease of Guam and Cadang-Cadang of the Philippines. The historical background of some of these diseases reveals that the name bud-rot was, at some time, applied to them. This circumstance of the term bud-rot is also of particular importance to the symptomatology of wilt diseases in the Latin American area.

Wilt diseases of the coconut palm have been traditionally grouped into two classes. These are: wilt diseases of known aetiology, when the causal agent is known; and wilt diseases of unknown aetiology, when the factor causing the disease is not known.

Those generally regarded as diseases of unknown aetiology are some of the diseases mentioned before, including Kerala wilt of India, and to some extent Bronze leaf wilt of Trinidad. When the causal agent of a disease is not known, particular attention must be paid to the symptoms and the development of the disease itself, from the appearance of the first symptoms to its conclusion. The particular way in which the disease spreads in a given area is also a characteristic feature in classifying diseases of unknown aetiology. Thus, for example, on the basis of symptomatology and epidemiology it was possible to conclude, (Maramorosch, 1964) beyond reasonable doubt, that Lethal Yellowing occurs both in the Caribbean and in West Africa. By the same method, some disease may be separated from each other.

Bud-rot and Wilt diseases in the Caribbean

The point I noted earlier about Bud-rot in the Latin American area can be alluded to now. Around 1900 all diseases of the coconut palm with a rotting bud were grouped together under the general name of Bud-rot. The work of Stockdale and Nowell, between 1910 - 1920, allowed this complex of diseases to be separated into three categories up to that time. There were;

1. Bud-rot due to Phytophthora palmivora (true bud-rot)

2. Red ring disease

3. Wilt disease, called West End Bud-rot. Finally called Bronze lesf wilt by Briton-Jones

In 1900, a certain disease called Bud-rot of coconuts was causing considerable anxiety in Trinidad, Jamaica, British Honduras, Cuba and Puerto Rico. It was reported as having occured around 1870 in Guyana. To this disease is attached also, a record of epidemic destruction of coconut trees in Grand Cayman as early as 1834.

After 30 years of destruction in Cuba, the industry was annihilated. There were heavy losses in Jamaica from 1891 to 1910. During the same period, compulsory destruction of diseased coconut trees was employed in Trinidad. In 1905, on one plantation in Trinidad it was reported that 2,000 trees out of 25,000 were lost within 6 months. Between the years 1909 and 1911, 18,068 diseased trees on small holdings were destroyed by the Government.

Causal Agent and Nomenclature

This particular Bud-rot referred to here was regarded as a bacterial bud-rot by Johnson (1911). Latterly, Nowell (1924) regarded the bacteria as secondary and Briton-Jones (1929) called the disease Bronze leaf Wilt; and he believed the disease to be confined to the Caribbean area including Cuba, Jamaica, Trinidad, British Guiana, St. Lucia and Tobago.

Briton-Jones, working in Trinidad, described the disease in Trinidad to be identical with the disease in Jamaica. Martyn (1945), who worked in Jamaica, described the disease as follows: 'The whole appearance of Bronze leaf wilt in the field is suggestive of an infectious disease. As no visible organism is to be found present in the earliest stages, and as the symptoms do not appear compatible with a non-parasitic disease, a disease of a virus nature must be considered a possibility ... The main features of the disease are its alarmingly epidemic nature where it does occur ..."

Whereas there was general agreement that the disease originally called bacterial Bud-rot or West End Bud-rot, now called 'Bronze leaf wilt' was the same in both Jamaica and Trinidad, Briton-Jones earlier (1929) considered the disease to be caused by a soil factor when he stated; 'whether or not an organism is associated with the disease is not known; but the very definite correlation between lack of drainage and the incidence of the disease indicates that the organism, if there is one, is secondary'. Thus in Trinidad, Bronze leaf wilt disease, overtly identical with Bronze leaf in Jamaica, was thought to be of physiological cause, whereas in Jamaica, Martyn expressed the view that the disease was caused by some organism not yet identified.

The method of controlling the West End Bud-rot - Bronze leaf wilt - in Jamaica was the destruction of diseased trees. But Briton-Jones (1929) and Bain later, (1940) considered the disease in Jamaica to be the same as the one in Trinidad which was supposedly caused by soil conditions. The immediate result of Bain's diagnosis was that cutting and burning of the diseased trees was abandoned. It was noted that the disease began to increase and assumed pandemic proportions.

In 1946, Leach attempted a comparison between the symptoms of Jamaican Bronze leaf wilt (though to be infectious) and the Trinidad disease. The comparison was made clearly between the non-infectious disease caused by drought conditions and not the infectious bud-rot type of Bronze leaf wilt. His analysis showed the diseased to be different.

Thus, based on the former assumption of Martyn that the disease was infectious, it was called the 'Unknown' disease and investigated by Nutman and Roberts (1955), who called it Lethal Yellowing. By this time the Jamaican coconut industry was threatened. Whereas this was so in Jamaica, effective control of the disease in Trinidad was never abandoned due to the presence of Red ring disease in Trinidad.

Superficially, the leaf symptoms of Red Ring disease are quite similar to Lethal Yellowing. These are both wilt diseases; with tyloses being present in the vessels in Red ring disease and a possible toxin in Lethal Yellowing. Control measures for Red ring disease were always in practice. There were immediate destruction of the diseased trees.

Red Ring Disease

The symptoms of Red Ring are well known. In younger trees (3 - 10 years old) there is a conspicuous discoloration of the lowest leaves which begin yellowing from the tip backwards. With the progress of the disease, the leaves turn reddish brown and begin to wilt progressively. Finally, the entire crown changes colour. Nuts are shed if an older tree is affexted. (Figures 2 and 3). The distinguishing symptom is internal. There is a characteristic red ring in the stem. From this the disease derives its name. The disease is always fatal. The causal agent is the nematode, *Rhadinaphelenchus cocophilus* (Cobb) (Goodey 1960), which is present in great abundance and the vector is the palm weevil, *Rhynchophorus palmarum* L.

The disease was recorded present in Trinidad in 1905 and later in Latin America. It is not present in Jamaica. Control measures have always been the removal of diseased trees by cutting and burning: latterly by poisoning of the diseased tree.

Bronze Leaf Wilt

Very commonly, during periods of intense drought, palms in the Aranguez areas on the outskirts of Port of Spain shows this affection. Most of the plants recover after the rains. Bronze leaf wilt, according to Briton-Jones, is not infectious, but a case of physiological wilt resulting from unfavourable soil conditions. Accordingly, Bronze leaf wilt is, therefore, not regarded, today, as a fatal disease necessarily; and its presence in the field should not give the indication of a disease which spreads.

Bronze leaf wilt almost always occurs in solid blocks (Figure 4) of trees and predominantly in older palms. The lower leaves of affected trees turn yellowish bronze from the tip backwards, while the younger leaves appear normal and green. In advance stages, all the palms show the same degree of bronzing. Recovery from Bronze leaf wilt is the expected norm. This occurs after the first heavy shower of rains.

Apart from the bronzing discoloration, the inflorescence shows no abnormality, the apex of the affected trees remain normal, the bud does not die. Production of nuts may cease completely since the coconut palm is always sensitive to drought. Nuts may fall but a cross-section of the nuts shows no malformation or discoloration. Since this disease is not fatal, no ontrol measures are necessary. Better soil-water relations have always caused relief from the disease. If confusion of symtomatology between a fatal infectious disease and a non-fatal physiological wilt occurs, the infectious disease, if not controlled, may develop to alarming proportions.

The epidemiology of disease of unknown aetiology would be most effective in segregating the diseases when, superficially, they resemble in symptomatology and prognosis. In prognosis, Bronze leaf wilt is the exception since it is not normally fatal. In epidemiology, one or two diseased trees occur in the vicinity of a red ring diseased tree 8 - 12 weeks. Bronze leaf wilt occurs in blocks. Lethal Yellowing is infectious and required a long period of build-up of innoculum. Isolated diseased trees can be miles apart, then a local epidemic begins.

Cedros wilt - Co-identical with Lethal Yellowing in Symptomatology

In 1976, an infectious wilt disease was reported from Cedros, Trinidad. The symptoms were co-identical with the West End Bud-rot (Figures 5, 6, 7) as recorded in the literature, and also co-identical with Lethal Yellowing as described today. The epidemiology was similar to the above disease. At the time over 4,000 trees were affected in one section of Singh's Cedros estate which had 1,000 hectares of coconuts. The neighbouring estate, St. Ann's estate,, was also affected. Isolated diseased trees were seen in Constance estate of 600 hectares of coconuts. A protozoan flagellate, Phytomonas sp. has been found constantly in association with the bacterium Micrococcus (agilis) roseus in diseased palms and Oncopeltus sp., Lygaiedae, and Mecistorrinus (Anileteuchus)sp. Pentatomidae are vectors to these micro-organisms. The weed Asclepias curassavica is the flagellate and bacterial host in the coconut agroecosystem.

Lethal Yellowing disease is now associated with mycoplasma-like organisms. Such organisms have been isolated from Lethal Yellowing trees in Florida. The Kaincope disease of coconut palms in Togo has co-identical symptomatology with Lethal Yellowing in Jamaica and Florida. At present, no mycoplasmalike organisms have been isolated from these trees. However, remission of symptoms of the disease has been had with the use of chlortotracyclin-HCL and Tetracyclin-HCL. (Figures 8).

In summary, the wilt diseases of Latin America are Red ring disease which is practically under control in Trinidad, but present in St. Vincent, Grenada and on the mainland of Latin America.

Lethal Yellowing which may be endemic to the area, but most destructive in Jamaica and Florida are present; Bronze leaf wilt, a non-infectious disease from which plants recover generally and Cedros wilt disease (Hart-rot of Surinam) an indigenous disease.

Movement of the Coconut palm and associated Pests and Diseases

As the palm became dispersed around the tropical belt the pests and diseases found in association with it in different localities may have been:-

1. brought in together with the palm as associated diseases in balance with the palm.

2. encountered 'de nouveau' in the area from similar genera.

3. recent migration of pests and pathogens to available niches.

4. modified from completely different hosts with the change of the ecosystem.

1. Associated Diseases in balance with the Coconut palm

Harries (1977) suggested the most likely sites for the introduction of the coconut to the Atlantic seaboard were some of the islands of the Cape Verde group, with Mozambique being the most probable seed source. The result is that coconut populations on the Atlantic coasts of Africa, America, and around the Caribbean are constitutionally the same coconuts in East Africa, India and Sri Lanka. Such populations may be susceptible to the same lethal diseases.

An expected feature of the non-selected palm is its ability to maintain a stable yield in a balanced condition with its numerous pests and parasites. Such a balance might be caused by different types of resistances. Polygenic types of resistance in coconuts would seem most likely. Imbalances in this system can occur from changes in cultural practices as when exotic genotypes are introduced into geographically isolated areas. Thus pathogen-host evolution may show alteration in direction allowing for randonized outbreak patterns in several locations of introduction.

This hypothesis might be applied to diseases like Lethal Yellowing which is reported from several district areas in West Africa, Florida and the Caribbean. Despite the problems of clear-cut symptomatological interpretation the evidence suggests a South Asian origin for the disease (Chiarappa, 1919).

2. Diseases encountered 'de nouveau'

It appears reasonable to assume a Latin American origin for Red ring disease based on the following arguments:-

a. The disease is present only in the Latin American area and only in those countries where the palm weevil, Rhynchophorus palmarum, the vector, is present.

b. R. palmarum is the species of Rhynchophorus localized in the American continent though other members of the genus are present in South-east Asia with enough diversity to indicate this area as the origin of the genus. Local 'red' variants of R. palmarum throughout Latin America repeat frequently the diverse colouration of the several species in South-east Asia. This also throws light on the origin of this insect and the fact that it has migrated to and become isolated in Latin America (Figure 5).

c. The red ring nematode, Rhadinaphelenchus cocophilus is not known to be present in South-east Asia, though a species resembling it has been reported on Areca palms in India. The nematode is known to be obligatory parasitic on coconut and oil palm in Latin America only.

d. The only ectoparasitic form of the nematode in Latin America has been reported from Surinam. This form is associated with Little-leaf disease of coconuts in the presence of the palm weevil as a pest of the same palms. Experimental evidence has shown that these ectoparasitic forms can cause red ring disease when they are injected into the healthy palms.

e. The evidence strongly points to the obligate parasite Rhadinaphelenchus cocophilus as a variant of this ectoparasitic form capable naturally of multiplying in the coconut palm causing disease and being carried by those palm weevils incapable genetically of removing them from their haemocoel. The nematodes are parasitic on such palm weevils yet do not multiply in them.

f. The origin of the disease results from a new association of an ectotype of the nematode capable possibly of being transmitted by other members of the genera Rhynchophorus. The implication is therefore, that quarantine measures are strongly recommended outside Latin America to preclude this form of Rhadinaphelenchus cocophilus entering new countries having other species of [illegible]

3. Recent Migration to Available Niches

The coconut mite, Eriophyees (Aceria) guerreronis (Keifer), is a serious eriophyid pest affecting the development of the fruit. It was reported initially from Mexico around 1960. Mention however, was made of the pest in the Island of Sao Tome and Principe near the coast of equatorial Africa only in 1977 and from Benin and the Ivory coast in 1967 and 1968 respectively.

In 1967, Venezuela reported its presence from the state of Zulia; Brazil, in 1968 and Colombia, 1969. It would not be surprising [illegible] if the mite is now present, yet unreported, throughout Latin America since it is also now known in the West Indies from Jamaica, Trinidad, St. Vincent and Grenada. An extensive survey (Hall, Hussey, Marian, 1979) undertaken to find natural enemies for the mite revealed the potential of the fungus, Hirsutella thompsonii for a role in biological control.

4. Modified from completely different hosts with the change of the ecosystem

Cedros wilt Disease and its Distribution

Cedros wilt disease (Hartrot) has now been reported from: Trinidad, Tobago, St. Vincent, Guyana, Suriname (Hartrot), Venezuela, Colombia, Ecuador, Mexico and Brazil on coconuts. These areas also coincide with the distribution of the flagellate host-plant, the milkweed, Asclepias curassavica and the associated milk weed bug, Oncopeltus sp. Observations for the disease should be made in other countries in this region where the host-plant and flagellates are expected to be present. Such areas are Jamaica, Haiti and Cuba. It is quite possible that whereas the primary vector, Oncopeltus sp. will move the causal flagellate to the coconut palm another secondary vector, possibly differing in other locations, but principally a Pentatomidae, might be moving the parasite around in the crown of the coconut trees in an estate. This will be the major cause of outbreaks starting with Mecistorhinus sp. as exists in Trinidad.

The Epidemiology of Coconut Diseases

The three major coconut diseases of Latin America have insect-borne pathogens and so the dynamics of these diseases are also a function of the population dynamics of the respective insect vectors. Epidemiology, basically, is the science of population of pathogens as these relate to the populations of hosts in the ecosystem; whereas, insect population dynamics deal simply with changes in insect numbers from an ecological standpoint.

Pathogen numbers in the ecosystem are only relevant to disease increase in epidemiological studies and often relates to inoculum potential and either facultative or obligate synergistic interaction of propagules on an infection count whereas insect population numbers relate primarily to the percentage of vectors each of which is capable of causing a new infection.

Generally, in biological studies dealing with the dynamic process of disease ('dy/dt' - the change in disease 'dy' with an infinitesimal change in time 'dt' - as a function of time, random variables, parameters etc.) functions of both non-vector-borne and vector-borne pathogens may be adequately described by the same general model. Where (r) rate of disease increase is proportional to the level of disease actually present (dy/dt = rate (r) times disease proportion (y) or (b) rate of disease increase is proportional to the amount of healthy tissue (disease-free) thus: $dy/dt = (r)(1-y)$. The fastest rate is at the beginning of the epidemic and the rate declines as the disease level reaches a maximum. Finally, (c) the association of both conditions where absolute rate of increase is jointly proportional to the level of disease 'y' and healthy tissue (1-y). Thus: $dy/dt = (ry)(1-y)$.

In considering the epidemiology of Lethal Yellowing in Florida and Jamaica (Mc Coy, 1976) determined infection rate based on (c) above where the change in proportion of disease with time was equal to a rate value times the proportion of disease present.

An analysis of thedata on disease spread collected by the Florida Department of Agriculture during the first 1.5 years of the Miami epidemic produced an apparent infection rate of $r = 0.21$ per unit per month based on a population of 3.5×10^5 coconut palms. Linear regression analysis of logits of monthly LY incidence produced a line having a correlation coefficient of 98%. Extrapolation of that line beyond mid-1973 closely approached the estimated losses of 1973 and 1974 and projected a 99% loss by 1977.

In evaluating control procedures for LY, groups of palms in parks, golf courses or uniform tree plantings were selected in areas where LY was active. LY incidence in those areas was monitored for 16 months and (r) found to range from 0.15 to 0.42. The lowest (r) values occurred adjacent to the ocean.

For comparison, (r) values were calculated from LY incidence data from Jamaica. In an insecticide-sprayed group of trees at Ross Craig (3) (r) was 0.31 while in an adjacent unsprayed group (r) was 0.28 ppm over a 5 month period. In another group of palms at Silverton, Buff Bay (r) was 0.15 ppm over 3 years. In coconut breeding plots, (r) calculated from resistance data for 'Jamaica Tall' palms was 0.08 and 0.04, a much slower rate than in Florida.

The analytical treatment of LY by such a model compares the disease to infection by airborne propagules. In the same way (r) defined by the equation $dy/dt = (ry)(1-y)$ is not a description of the epidemic process but a form of speedometer. There is no reason to assume that (r) will stay constant throughout the epidemic. The factors of the environment which tend to make significant change in (r) will relate to the mode of propagation of the pathogens. In all this however the distribution should be made that (r) indicates the rate per unit of infected tissue and not infectious tissue. This should be so since pathogens and vectors may have several distinct forms of relationships from mutualastic to accidental.

Table 1

Mean apparent infection rate, (r), of Lethal Yellowing of Coconut palm in Jamaica and Florida

Location	(r) per unit per month	Time Period
Florida - Dade County	0.21	20
Florida - Golf Courses	0.42	16
Florida - Shoreline	0.15	16
Jamaica - Ross Craig	0.30	5
Jamaica - Buff Bay	0.15	5
Jamaica - Breeding Plots	0.06	36

During the early studies on Red ring disease, Hagley (1963) noted a correlation between red ring disease, palm weevil abundance and rainfall. The incidence of red ring disease and the fluctuations in palm weevil population density were recorded. The total monthly rainfall was also recorded for the area. The heaviest losses due to red ring disease occurred at the end of the wet season and in the first 2 - 3 months of the dry season, i.e. between December and March. The weevil population began increasing towards the end of October reaching a peak in December and falling in January and February. In March, the population again increased thereafter falling considerably throughout the latter part of the dry season and early rainy season. As the records of the incidence of the disease were based on the first appearance of external symptoms, which became manifest 6 - 8 weeks after initial inoculation of the palm, the actual period of highest disease incidence corresponded with the time of greatest weevil abundance.

Further, emphasis must always be placed on the relationship between vector and the pathogen; the then unresolved work of Fenwick, (1967) on attempts to control weevil abundance which Hagley found strongly correlated with increase in (r) should make this clear.

He described experiments carried out on field control of the palm weevil using BHC in the form of Agrocide '3' and Endrin. The results of both the Endrin and Agrocide trials indicated that monthly application of these chemicals to the leaf axils of coconut trees was likely to reduce incidence of Red ring disease by approximately one third. Less frequent applications were ineffective.

The relationship between weevil densities and Red ring losses however, was more ambiguous and uncertain: thus in the Agrocide trials on overall reduction of 50% in weevil densities only resulted in a fall of one-third in red ring losses: further, a reduction of weevils by approximately 30% on the two-monthly treated Agrocide plot was not accompanied by anyreduction in losses. Conversely, reduction in red ring losses by approximately one-third on the one-monthly and two-weekly Endrin plots occurred without there being any apparent reduction in weevil population.

A further point was that the monthly incidence of red ring on the separate plots did not pp ear to be connected with fluctuations in weevil populations.

The logistic model is appropriate to the rate of spread of red ring disease much more than can be said at present for LY. That the rate of spread is influenced by the level of diseased tissue relates to the habitat of the palm weevil which is the diseased coconut palm preferably, but the vector palm weevil must develop in the diseased tree even if other palm weevils developed in healthy palms. Therefore, dy/dt must increase with y. On the other hand, the availability of (1-y) healthy tissue is the necessary source of attraction for the vectors to produce new disease.

The following implications in the rate of spread are discussed by Mc Coy for LY:

Effect of Removals; It was apparent that the removal of diseased palms from the epidemic by death predicated a spread value greater than (r). As diseased palms died, they no longer served as sources of inoculum and subsequent spread must come from only those diseased trees that are still alive, considering that they were dealing with an obligate parasite. The proportion of palms serving as inoculum sources was therefore less than x, and the actual infection rate must accordingly be greater than the apparent rate, (r).

Effect of Locality: It was noted that the lowest (r) values for LY in Florida were adjacent to salt water. This had also been reported as characteristic of Kaincope. In the 1955 LY epidemic in Key West, Florida, 75% of the coconut palms there were destroyed. A ring of tall palms surviving that epidemic, however, still remain around the circumference of the island. In an LY epidemic in Florida, all susceptible coconut palms had invariably been destroyed in any inland site of infestation within 3 years, The factors associated with this salt-water phenomenon were unknown; they may reflect vector distribution, positional effects in relation to other palms, or a change in host physiology. This phenomenon had not been noted in Jamaica.

The extent to which increase birth-rate of new diseased trees depend on inoculum from diseased trees can be observed by the rate of increase as it correlates with the abundance of infectious material. However, this would have been seen best prior to the onset of the epidemic when the ratio of non-infected trees was highest. On the other hand, if one is dealing with an uncontrolled vector that is independent of infected tissues then fluctuations of disease, under the pressure of phytosanitary measures, will relate more directly to the fluctuations in abundance of the vectors.

In the case of Cedros wilt disease, transmission rate of the protozoan flagellate by Oncopeltus sp. does not directly involve the diseased palm since the insect vectors live on a weed, Asclepias curassavica, in the agroecosystem with the coconut. Further the pathogen is in virtual mutualism with Oncopeltus. Thus, an initial model for (dy/dt) could infer that increase is proportional to the amount of healthy tissue '(1-y)', since there would be no direct correlation with diseased tissue. A plot of 'dy/dt' vs time would have the form of a negative exponential probability density function. The fastest rate would occur at the beginning of the epidemic and infective tissue would not contribute to the future of the disease.

The major consideration that replaces 'y' is the 'abundance of vectors'. A clear indication of such a situation is the 'season' of a disease outbreak which would correlate with the abundance of insects during a season or during cycles of insect increase. Such outbreaks might relate to such normal phenomena as insect migration. The same would relate to pests in the agroecosystem. For the moment, one may examine instructively some well known pests to determine the physical and biotic factors exerting a check on the population density.

From time immemorial, the rhinoceros beetle, Oryctes rhinoceros L., has been recorded as a pest of the coconut palm in its Asiatic homes particularly within the tropical and sub-tropical belts of the oriental region. But it is a well known fact that the population density and severity of infestation of this beetle is more marked and widespread in the Oceanic islands, where it had been introduced accidentally, than in its original habitat. This reduction in severity of infestation in the main land home is due to the lesser population density of the pest but can be attributed mainly due to the suppression of pest multiplication by the physical as well as biotic factors associated with the breeding sites of the beetle.

Physical Factors

Exploratory studies (Anthony and Kurian, 1975) made in some of the prominent coconut growing states of the Indian Union revealed that the cattle dung which forms the major source for the breeding of the pest is stored in different ways depending upon the local climatic conditions, cattle population, agricultural practices etc., in each of the localities and also based on the economic status of the cultivator. In Karnataka, Tanukbady and Andhra Pradesh where herds of cattle are reared, huge quantities of dung are stored, mostly under exposed conditions subject to sun and rain. In Kerala, which is under the influence of the heavy showers of the two monsoons where cattle population is sparsely distributed, the dung is stored comparatively in smaller quantities in pits or as heaps under roofed conditions. So, also in areas under multi-cropping cattle dung is seldom stored for long periods. Progressive farmers use 'Pucca' manure pits for storing cattle dung. Thus cattle dung which forms the major source of breeding media for all stages of Oryctes is subject to varied conditions of physical factors particularly temperature and moisture.

Temperature and moisture up to a particular level is congenial for the multiplication of the pest whereas beyond and below that level it is detrimental. Breeding of the beetle was observed in cattle dung under a temperature range of 10° - 50°C and 30 - 60% moisture. But maximum breeding was observed in comparatively smaller quantities of 5 - 10 cu. ft. of cattle dung having a temperature range of 20 - 40°C and a moisture level of 40 - 50%. Above 80% and below 5% moisture no breeding took place. So also at a temperature above 60°C and below 10°C no stage of the pest was observed in the breeding sites. Another factor which is responsible for the destruction of the different stages of the pest is the physical removal of cattle dung andcompost. In Kerala, the necessity for keeping cattle dung for very long periods seldom arises. So the sites are disturbed and material disposed of frequently for manuring thus exposing the various stages of Oryctes to its natural avian and mammalian enemies.

Biotic Factors

Among the metazoans, particularly insectan and non-insectan cohabitants, found associated with the different stages of Oryctes rhinoceros in its breeding sites, particularly cattle dung, the most common and widely present natural enemies are the insect predators. These include the histerid, Santalus parallelus Payk., the elaterid, Agrypnus bifoveatus Candeze, four species of Scarities including Scarities indus (Carabidae). Indoscitalinus anacnoreta Er., and Philonthus Cintula Gr., and the two other species of staphylinids, Herpalus (paridelus) indus Bates, Harpalus sp., Pheropsophus sp., and Catascopus sp. of the Carabids, Chelisoches Moris F. of Forficulidae, Gryllctalpa africana P. de B., Gryllidae; Parachytrupes portentosus Licht. Gryllotalpidae, and one species each of the Asilidae and Formicidae. No scollid parasite of primary importance has so far been observed from any of the regions explored except in one or two instances where Scolia evanipenis Fbr., Campsomeriella collaris Fbr., have been found associated with the breeding sites of Oryctes.

The non-insectan metazoan groups are the acarines and nematodes. The mites of the family Ascides and the nematodes or Rababditis species were also observed associated with the early stages of the beetle. Mites and nematodes attacking the advanced stage grubs of Oryctes were met with in the Lakshadweep Islands. Death of rhinoceros grubs due to fungal and bacterial pathogens are also quite numerous. The most common among the pathogenic organisms are the fungus Metarrhizium anisopliae (Metschnikoff) Sorokin and the bacteria Serratia marcescens, Pseudomonas sp. and Sarcina sp.

Interaction of pests with pests

Rhynchophorus ferrugeneus is one of the most harmful and notorious pests of the coconut palm. This pest is often associated with Oryctes whose activities provide it with noches for ovipositing. In this case, the association is not one of competition. Similarly, the interaction of scale insects with ants is well documented. This situation is not unlike the previous one. Pests may also interact with the physical environment. Very often the wet weather brings with it numerous outbreaks. This is well known in India.

The nature of pests in the ecosystem is such that leaf feeders belong to special niches, similarly stem borers and other pests of the palm. These insects all interact with each other at various levels of the ecosystem. Such pests throughout the world are interchangeable since they belong to the same available niches. To some extent, this relates to the coefficient of distribution mentioned before. There is with all pests which feed on the same plant an element of competition. Such an apparently ' individual force' limiting pests population, may appear to be 'correlated with inaccessibility of food supply' or if even enough food seems to be available - 'effective food' may not be. In the first instance, one may consider the effects of some defoliating caterpillars (Lepidoptera).

Brassolis sophorae - These larvae causing intense defoliation. Sometimes the palm dies especially in the wet season. Recovery of debilitated plants may take about two years. During this period of activity of B. sophorae no other leaf-feeding insect may survive. In others, it is seasonal. Competition is such, in this case, that this insect mutually excludes any other leaf-eating insect.

The simultaneous presence of several leaf-feeders may result in lack of 'effective food' for all. That is, many insects may not be able to complete their life cycle on whatever remains.

The immediate discussion on the size of population of an insect pest with regard to interactions with other insect tends generally to stress the role of parasites and predators. That is: the carnivorous aspects of the food chain which provides intense biological 'resistance' to the pest and so keeping it in check.

Extensive and long term research done by several workers on the regulation of population density (Pickett et al, 1946, 1953; Lord, 1947, 1949 etc.), have shown this situation to be so with more than half the number of species examined. In about one-quarter of the number, natural enemies are not sufficient to keep the population below an economic injury level. Yet, in others, population fluctuations was clearly correlated to the accessibility of food supply.

In a word, therefore, the indication is that nautral forces alone do not always keep insect populations in check and it is not possible to rely on them completely. In fact, the direction of theprocess of the ecosystem tends towards their increase, at least in the short run of the faunal population. This situation applies also to the vectors of plant pathogens and their development on alternative hosts when the transmission of a pathogen to the palm might be due to incidental feeding mainly.

Search for a vector to Cedros wilt

Prior to the recognition of Cedros wilt as a separate disease from red ring disease the poisoning of all diseased trees with an organo-arsenate compound, immediately as the symptoms were definite would kill the pathogen for red ring and any insect vectors therein. This practice did not control the outbreak of Cedros wilt which was presumed to be red ring disease. The peaks for disease incidence were more or less monthly, thus the vector lived and developed in the field and has a 30-odd day life cycle on a collateral host with the pathogen. Observations on the estate weed population showed a high density of the milk-weed plant, *Asclepias curassavica* with *Oncopeltus* in the affected fields.

The 30-day life cycle suited *Oncopeltus cingulifer* on the milk-weed plant. On examination for flagellates of the promastigote type found in the coconut palm, *Oncopeltus* contained similar flagellates. Often, however, the milk-weed plant was immediately below the affected coconut palm.

The probability of infection of the coconut palm by chance-feeding is reduced if only a small percentage of the insects contained flagellates - unless a population of the bug was correspondingly enormous, to compensate for the small percentage of vectors.

The following observations were noted from planned experiments: All *Oncopeltus* adults and nymphs on coconut estates contained flagellates (412/413). The flagellates were not transmitted through the eggs of *Oncopeltus*. There were no flagellates in nymphs which were not exposed to milk-weed plants with flagellates. The flagellate was not entirely an insect-modified one since a plant-cycle was necessary for its normal survival. Observations were next made on migratory *Oncopeltus* in remote areas of the country where they were expected to alight. They were found feeding briefly on the leaves of coconut trees. The feeding site was therefore known.

The Vector and Epidemiology of the Disease in Analytical Studies

In studying the epidemiology various factors mentioned above interact to produce a pattern. Various models may be worked out to determine the rate of spread in different seasons or different periods of the day etc. They all relate, however, to the insect as it functions in the ecosystem. Thus the presence of predators may parallel the rate of spread or vice-versa. Often with diseases of unknown aetiology the special epidemiological pattern is important for their separation. But the nature of the association between the plant pathogen and the vectordetermines the mechanism of transmission.

First, the ability of the pathogen to survive outside the plant host determines its need and the mechanism of transmission. This may determine its relationship to the insect. Secondly, the longevity of the pathogen in the insect may determine its rate of spread from host to host. Thirdly, the proportion of vectors in the population may determine the extent to dispersal. All the insects of the population are not necessarily vectors even in mechanical transmission of some pathogens. Fourthly, the relationship between the vector and other organisms of the ecosystem is important, since vectors exist in a definite niche usually. Finally, the pathogenicity of the organism on the vector relates to the extent to which the pathogen limits the vectors and the degree of affinity one for the other.

A striking corrollary to these is the inability of a given vector to find a niche in a particular agroecosystem. In a condition where for example, a vagrant vector enters a coconut estate intercropped in a particular way such that presents an incompatible micro-environment, it may infect one or two healthy palms, according to the nature of the transmission sequence, but if it does not carry on its life cycle on the coconut palm it will move on to a more compatible environment to multiply. Thus leaving that area free from outbreak of the disease.

Whereas Red Ring disease is generally present wherever its vector is present in Latin America, and absent where its vector is absent. One may just speculate on the localization of Lethal Yellowing with regard to the isolating mechanisms of the ecosystem. The disease appears to be contained in the Western Atlantic Ocean and Caribbean Sea. Whereas, the other diseases at present are more southerly in Latin America. One principle of course in vector borne diseases is, the vector must find, at the time of its introduction an available niche even though every agro-ecosystem is characteristic. This tends to ward off the disease for some time. On the other hand, pathogens without vectors can be more ubiquitous in such uniformly humid area as coconut plantations the world over. This is the case with Phytophothora palmivora Butl., causing bud rot disease of coconuts throughout the West Indies and the world.

The application of pesticides in the control of vector-borne diseases in coconuts

Whereas 'disease' denotes a condition of malfunctioning in the plant occasioned by continuous irritation due to the pathogen, the term 'vector-borne disease' should be taken here only as a short-cut definition to imply diseases due to pathogens which are insect-borne. Thus, implicitly, one is concerned here only with such pathogens and their vectors.

Principle in control measures

In principle, one may reasonably consider the probability of controlling such diseases via either the vector or the pathogen; or, logically when possible also, by both simultaneously. Theoretically, one seeks usually the weakest link in the chain of transmission events to restrict economically, the spread of the particular disease. Eventually, one aims to preclude any source of the inoculum to the healthy suscept. This last measure might lead into the realms of an alternative plant host and even a different primary vector associated with this collateral species.

The possible combinations of all the above elements exist naturally, often they are based on the nature of the relationship between pathogen and vector in the first place, at the level of the crop as an agroecosystem with all its intrinsic peculiarities. But when it is based also on the relationships of a collateral host with its own microsymbiont-vector, and these may include a different habitat, then new factors come into play such that the type of pesticide required might be in a completely different category: a herbicide instead of an insecticide, for example.

I have to emphasie one other feature to which this section addresses itself. That is the aspect of 'tropical crops'. What is really important here is the tropical environment. The distinct feature is the continuity and abundance of active animal and plant life at virtually the same level throughout the tropical year; whereas in the temperate zones the partition provided by the low temperatures of winter often allow for sufficient phenological prognostication when the ambient temperature rises and allows for entomological and phytopathological work to be normalized at a calendar basis. Phenograms may be made which allow one to predict periods of maximum emergence of insect vectors or their hosts, primary or alternate, and also the periods for infection.

One can still, however, find a suitable parallel in the actual production of a tropical crop. Some crops like rice, Oryza sativa, pigeon peas, Cajanus cajan, are naturally photoperiodic and so flower at distinct times of the year only. This allows for easy prediction as to the advent of pod-norers and any such vector that depends on flowers and fruits in their life-cycle. Generally, there are in fact simple organized growing seasons for numerous short-term annuals like tomatoes, peppers and cabbage in the drier days with cooler night temperatures enough to allow some seasonal prediction on the basis of the crop itself though not necessarily on the entire environment as in the temperate regions. In the case of perennial crops, however, their agroecosystems represent remarkably stable tropical communities of interdependent flora and fauna, with continuous energy for growth and perhaps with many external linkages for general maintenance. Prediction here deals with the understanding of the dynamics of the populations under surveillance instead of climatic fore-casting.

It is this fundamental principle which overrides any other in the understanding of the control of vector-borne pathogens and their vectors in tropical agriculture. Features as the threshold density of a vector for transmission to come about, genetic potential for transmission, and the joint abundance of other insects and the nature of the pathogen-plant relationship become more relevant than simply the presence of the vectors and the presence of the plant suscept.

Perhaps I should illustrate this important principle by an example. Red Ring disease is a fatal disease of the coconut palm in the West Indies and Latin America. The causal agent is the nematode *Rhadinaphelenchus cocophilus* and the vector is the palm weevil, *Rhynchophorus palmarum*. Before the palm weevil was confirmed as the vector, correlation studies were done to compare the abundance of the palm weevil population with the abundance of diseased coconut palms. There had always baeen a positive correlation. Naturally, therefore, controlled reduction in the population of the palm weevil should mean a consequent reduction in the abundance of diseased trees in a given time. But experimentally, by the use of different insecticides, this did not turn out to be so. Similar studies were done later by Fenwick utilising different insecticides which gave a definite reduction in insect numbers, but no reduction at all in the rate of infection and the abundance of diseased trees, despite the variety of application rates and frequencies of the treatments. Later it was found out that only about 8% of the palm weevils were in fact capable of being vectors and these generally emerged earliest to infect the healthy palms. The answer to the problem was really that the insecticides never reached their targets, i.e. the actual vectors of the nematodes.

Now, this phenomenon that only a certain number of insects of a vector species is sometimes capable of transmitting the pathogenic organism is not a tropical phenomenon, it is instead an entomological reality of widespread occurrence; but the salient feature in the control of vectors to red ring disease is the principle of diversion. Vector insects had to be diverted awaw frm the leaf-axils of the coconut palm where they normally introduced the inoculum to the tree. Such was done by the use of attractive coconut tissue and an insecticide like Lannate (R) which did not interfere with the attractant alcohols emanating from the tissue. The guard-basket was therefore an effedtive diversion principle and a selective trap for all the palm weevils on an estate including those few insects which were the vector types.

In another regard, the nature of the selective mechanism which produces vectors from a population of non-vectors is of special importance. In the above example, we considered non-vector insects as the normal population. There are of course situations where vectors insects are the most frequent and abundant of the normal population. The process by which this position is generated naturally can explain its importance in the agroecosystem. Let us examine a temperate example. The transmission of Curly top virus to sugar beets in the field by the beet leafhopper, Circulifer tenellus (Baker), is influenced among other things by the vector population during summer, the percentage of viruliferous and the abundance of plant reservoirs of the virus. Viruliferous leafhoppers may sometimes constitute between 0-90% of the population and the proportion of the viruliferous insects increases during the summer with the overwintering females retaining their infectivity. It is clear that in this case for control of the disease though the control of the vector, that insecticides have to be applied to the breeding ground of the insect before it is able to move out to the cultivated fields in the spring. This picture of course changes with another vector and virus combination as with Macrosteles fascifrons (Stal) and aster yellow virus. The six-spotted leafhopper, as it is called, sometimes is between 5-14% viruliferous in June in Wisconsin, and in September, 0-1% only. Obviously, the mechanisms by which these two situations are effected appear quite different. But, for the moment consider either of these two situations in a tropical orchard where there is no dormancy of winter to regulate the numbers of the vectors.

Let us refer again to red ring disease as working example. The mechanism which allows for the transmission of the nematode might be considered as a lapse in the defence mechanism of the insect. Essentially, when the larvae of the palm weevil develops in the diseased coconut palm, hundreds of red ring nematodes are ingested with the stem tissue on which the larvae feed. These nematodes penetrate the gut wall and enter the haemocoel where they are normally lysed by enzymic mechanisms located in the blood of the insect. The enzyme appears to relate to one gene. When the allele is dominant, even heterozygous, the larvae normally destroy the visiting nematodes which is fact would subsist as parasites in the insect but not reproducing. However, when the homozygous recessives are present, the enzyme mechanism is absent and the developing insect is defenceless against the invasion. These nematodes remain during the metamorphosis of the insect and are present in the ovipositor of the starved diminutive adult female with a few eggs to be introduced into the healthy coconut palm. Thus, the tendency is for vector populations to be self-limiting in certain contrived conditions.

Source of the pathogen and control measures

Effective removal of the source of a pathogen to a crop plant is really the key to the control of the disease since by definition disea e is incited by the pathogen. The source may be within the crop agroecosystem in the diseased crop-plant or a weed, as an alternate host, or the insect vector when the vector-micro symbiont relationship borders on mutualism. In virus diseases, propagative viruses which are transoverial from generation to generation represent a continuous source of inoculum to the plant. Green rice leafhoppers in tropical Japan spread certain virus diseases and also mycoplasma-like organisms. Nephotetix spp transmits a nonpersistent virus, tugro disease, and are predominantly and economically important species. The maintenance of the virus is either in the host inse t or the rice plant. To reduce and eliminate the inoculum sources of virus, the removal and destruction both of diseased plants and ratoons are practiced. In any event, both long term and short term measures are employed with resistant varieties in mind. Short term practices do not alone control the disease because of the inability to remove completely the source of inoculum.

In the case of certain tree-crops where the source of the pathogen is really the diseased plant, destruction of the diseased tree reduces the spread of the disease. Notable examples of this are the poisoning of red ring diseased trees, and sanitary measures in swollen shoot disease of cacao. In these two examples for the treatment to have any permanent value the unanimous cooperation of all the farmers must be had. To this end, the expedient of 'cordon sanitaire' was exercised in Ghana. The pesticides utilised here are herbicides instead of insecticides. This practice in certain diseases can be effective and almost final when the insect vector also develops within the diseased tree. This is the case of red ring disease. Therefore, properly timed poisoning also eliminated the actual vectors before they are released to the field.

On the other side of th picture, tree poisoning is practically useless when the source of the pathogen is not the diseased tree. One example of this is the picture of lethal yellowing disease in Jamaica and Florida. Often, onset or the disease begins with a single diseased tree or two in an area. Generally a pattern of tree-hopping obtains. The second phase of the disease may occur 6-12 months after near the infected tree. The poisonihg of these diseased trees never halted the disease. It would appear instead that the incoming vectors are capable of multiplying in the coconut field and transmitting their infection from one generation to another over a certain period of time. It would appear then that control measures which utilize insecticides would best be done in an under-cropping system where insecticides are utilized also for that crop in the lower storey.

The effectiveness of such control measures based on source climation can be fully appreciated with this example, again from coconuts, a crop with which I been working for the last sixteen years. The identical poisoning measures using 'Silvisar 510' were utilized for all diseases resembling Red Ring Disease in Trinidad. However, in one region, Cedros, the method was not working anymore or so it appeared. Two estates had an alarming and unusual increment of disease despite the control measures: respectively 2518 and 2519 diseased trees. On closer examination, this was discovered to be another disease caused by a trypanosomatid protozoan where the source was a weed in the field Asclepias curassavica, with its own insect fauna, Oncopeltus cingulifer which visited the coconut palms for incidental feeding only. The coconut palm was a new host for the protozoan flagellate and was fatal to the tree whereas there was no effect on the weed. Control of this disease was the elimination of the source plant from the field.

The utilization of pesticides only in control measures

In tropical life, the importance of the agroecosystem is obvious as a controlling factor to insect population growth; when the use of pesticides disturbs the pattern of energy flow and control is modified serious problems occur especially so with the case of vectors and their pathogens. Adjustments can only be made in the longrun since there is no winter period which might naturally rectify, to some measure, the change.

Consider now the effects of the utilization of various insecticides against the palm weevils in these coconut agroecosystems. Resistance to the insecticides will develop. How it will turn out is anybody's guess. One thing is certain though, the vectors will not be destroyed as was previously shown. But the palm weevil can be a pest in its own right. The use of insecticides in the wrong way can in fact cause this, as parasites and predators are gradually removed. This may be a pest flareback of a different nature. One general feature about vectors is that they, on their own, do not normally cause damage to the crop, but the constant use of insecticides to prevent disease can cause new pests to appear in the tropics very readily on a crop with a vector-borne pathogen.

Patterns of control in red ring disease

The palm weevil, Rhyncophorus palmarum L. is the vector of the red ring nematode, Rhadinaphelenchus cocophilus (Cobb, 1919) Goodey, 1960. Disease in new plantations generally begins with an infected 4-10 year old palm, the vector weevil having immigrated from a diseased estate. From this diseased tree the new estate may become infected and the disease, endemic in the long-run. Effective patterns of control may be employed during several phases of the development of the epidemic.

Phase I. Primary Infection and Inoculum Source

The rate of spread from this infector plant depends upon the development of vector palm weevil within the diseased tree. These are homozygous recessive for the ability to remove the parasitic nematode from their haemocoel. This parasitism may limit the number of developing vectors and reduce the size, fecundity and longevity of the vector adult to very significantly low magnitudes. After 3 months from infection a new tree is infected by the one vector (83%) emerging from the infector plant. This insect is usually infertile though eggs are present. The nearest susceptible tree is infected. No vectors will develop from this infection and the infection may die out. These only form a source of inoculum as the diseased trees are attractive to palm weevils. Phytosanitary measures of control are most applicable at this time.

Phase II. Invasion and Secondary Infection

Invasion and secondary infection begin when other field insects are attracted to the standing diseased trees to mate and oviposit. Their progeny are of several genotypes (RR, rr - vectors, Rr); with the quantity of progeny depending on size and age of the infected tree and stage of infection (i.e. space, food and intra and interspecific competition). Vectors resulting from these will be fertile since there is opportunity for mating.

Phase III. Beginning and Logarithmic Phase of the Epidemic.

Fertile vectors developing from heterozygous matings and vectors by vector mating increase and maintain the increment of disease. Secondarily infective weevils are limited by cannibalism of larvae within the diseased tree and the longevity of the insects in the field. Nematodes are unlimited in this phase since diseased trees contain millions of the persistent infective stages of the nematode. Finally, decomposed trees have no nutritive value and attractive influence on the palm weevils and nematodes do not survive in the soil for more than 48 hours.

Phase IV. Population Increase of Vectors and Non-vector Weevils

Non-vector palm weevils live for about 30 days in the field and disperse from leaf-axils of diseased trees or wounded trees emitting attractions; or following the insects which wound the plant first.

Fertile vector insects are short lived. These oviposit and cause increased insect population. Insecticidal sprays affect these populations mainly. Traps for reduction of insect population capture these insects. An abundance of vector insects in traps (insects less than 30 millimeters from the tip of head to tip of abdomen) indicate abundance of disease likely and mating potential with male vectors (rr). Since all diseased trees are breeding grounds for insects, the poisoning of diseased trees are reducing their attractiveness is essential to the reduction of disease and insect population increase. In older trees palm weevils develop in inflorescences and spathes and some petioles which are of no potential in nematode transmission. Older trees, therefore, break in the link in disease spread. Other diseased trees, Cedros Wilt, Bud rot may attract palm weevils to oviposit. Cedros Wilt limits insect development.

Analysis of Control Measures

(a) Application of Insecticides

1. Insecticidal application to all trees in an estate usually does not give ready control of red ring disease. This relates to weevil abundance and mobility of non-vector insects in the logarithmic phase of the epidemic. Insecticides will give:-

(1) Protection and be

(2) Eradicant for insects

and (3) Require constant application.

2. Insecticides placed on diseased trees act as eradicant for insects and baits for both vectors and non-vectors. These reduce spread of disease.

(b) Non-insecticidal Treatments

1. Removal of diseased trees by poison or burning allows elimination of inoculum source and removal of host for insect development and infection.

2. Application of biological control measures; bacteria, viruses to leaf-axils of diseased trees where insects are prevalent reduces insect population.

(c) Integration of Control Measures

The balance of control patterns including non-insecticidal and insecticidal measures swings from disease abundance to weevil abundance and how these relate.

The origin and method of transmission of micro-organisms associated with Cedros Wilt disease of coconuts

Symptoms and distribution of Cedros Wilt disease

The characteristic symptoms of this disease, Cedros Wilt or "La Marchitez de los Cedros" in Latin America and 'Hartrot' in Surinam, are as follows: there is, initially, a sudden wilting of the lowest leaves of mature trees progressing in order upwards around the stem, but not affecting the crown leaves. This phase may be very rapid, within a fortnight; or progress slowly during 6 to 8 weeks. The second major characteristic of the disease is the death of the terminal bud and the putrefaction of the heart. This results in the complete breaking-off of the crown with green leaves which are only slightly wilted when the original phase is a rapid wilt. Nut-fall is characteristic. There is a dry necrosis of the inflorescence beginning at the tips of the rachis. In advanced cases, the unopened inflorescences are necrotic. The affected mature fruit shows a blackening of the endocarp. Internally, the stem shows no discoloration. The roots show some drying-out with cortical decay. Palms of all ages are attacked.

Usually, the diseased trees are single and isolated among healthy palms. Less frequently, a group of 2 or 3 contiguous palms develop symptoms, in tandem, within 2 months of each other. Infrequently, clusters of 6 - 8 trees are found to reveal a similar succession of infection and death. In cases of outbreaks, large tracts of disease develop following the same pattern to destroy several hundred hectares.

The international distribution of the disease coincides with that of the milk-weed, Asclepias curassavica, Asclepidaceae, which is present on the coasts of Central America, the West Indies and South America as far as Brazil. This typical weed houses the protozoan flagellate Phytomonas elmassiani in the latex vessels and hosts insects of various species of Oncopeltus, an animal host to the flagellate. These 3 organisms are produced in the coconut agroecosystem i all countries where the disease has been found: Mexico, Ecuador, Guyana, Venezuela, Trinidad and Tobago, St. Vincent and Surinam.

Associated Micro-organisms

Two species of micro-organisms have been found in diseased palms internally associated in the phloem elements. These were a protozoan flagellate, Phytomonas sp., and a bacterium, Micrococcus (agilis) roseus. The flagellates were first found by Waters (1978)[3] and the bacterium by Griffith (1977)[2].

1. Preliminary Bacterial Studies

Micrococcus (agilis) roseus was almost consistently isolated from the palms when flagellates were also observed. The bacterium was observed both as a red pigmented motile form and as a white variant. Indications were that the bacterium remained in the sieve tubes of the palm together with the flagellates.

In an attempt to determine the possibility of a bacterial induced wilting, 500 ml of a high concentration of (100,000 C.F.U./ml) of the bacterium were injected into the trunk of 5 adult coconut palms to move with the transpiration stream. The bacteria were recover le in the leaves 48 hours afterwards.

The injected trees showed no mal-effects up to months afterwards. Thus, the bacterium did not produce wilt in theusual way known of organisms like Pseudomonas sp., Xanthomonas sp., Erwina sp., and some Corynebacterius sp. Since its saprophytic nature is recognised it was thought to function as a micro-commensal immediately as the cells die in the affected tissues.

2. Preliminary Flagellate Studies

These were of the promastigote form, packed densely in the sieve tubes. They were not seen in the xylem vessels or the associated parenchyma of the stem. Normally, the flagellates, being on an average 20 um in body-length were oriented length-wise in the mature sieve cells. On expression from the tissue, many had a twisted corpus with the flagellum length about 7-8 um on an average. In a few instances, an oviod amastigote form, about 8 um in diameter, was observed.

The high density of the flagellates in the active phloem elements indicated the adequacy of the feeding-ground for these organisms. This high population would starve the host. Starvation would affect the roots seriously eventually causing dysfunction jointly with the actual invasion of the root phloem due to vertical migration of the parasite.

Search for a vector to Cedros Wilt.

Prior to the recognition of Cedros Wilt as a separate disease from Red Ring disease the poisoning of all diseased trees with an organo-arsenate compound, immediately as the symptoms were definite would kill the pathogen for Red Ring and any insect vectors therein. This practice did not control the outbreak of Cedros Wilt which was presumed to be Red Ring disease. The peaks for disease incidence were more or less monthly, thus the vector lived and developed in the field and had a 30-odd day life cycle on a collateral host with the pathogen. Observations on the estate weed population showed a high density of the milk-weed plant, *Asclepias curassavica* with *Oncopeltus* in the affected fields.

The 30-day life cycle suited *Oncopeltus cingulifer* on the milk-weed plant. But in the other fields where there were *Sida* sp., numerous *Dysdercus* sp. were present. On examination for flagellates of the promastigote type found in the coconut palm, both *Oncopeltus* and *Dysdercus* contained similar flagellates. Often, however, the milk-weed plant was immediately below the affected coconut palm.

It is easier to identify a bacterium by physiological or morphological studies than it is at present for the protozoan flagellate. Therefore, the red *Micrococcus* could be used as a marker or tracer to determine the origin of the flagellates in the coconut trees.

Generally, the bacterium found in all the milk-weed plants were white, as would be found in the coconut palms sometimes. Then on further growth the colour changed to red. Such was found in all locations all over Trinidad. An examination of the haemocoel and salivary glands of *Oncopeltus* for the bacterium was undertaken accordingly. The bacterium was generally the yellow variant originally; then on transfer, some cells changed to either the white or red form.

The probability of infection of the coconut palm by chance-feeding is reduced if only a small percentage of the insects contained flagellates- unless the population of the bug was correspondingly enormous, to compensate for the small percentage of vectors.

The following observations were noted from planned experiments. All Oncopeltus adults and nymphs on coconut estates contained flagellates (412/413). The flagellates were not transmitted through the eggs of Oncopeltus though the bacterium Micrococcus was in 9 out of 76 eggs. There were no flagellates in nymphs which were not exposed to milk-weed plants with flagellates. The flagellate was not entirely an insect-modified one since a plant-cycle was necessary for its normal survival. Observations were next made on migratory Oncopeltus in remote areas of the country where they were expected to alight. They were found feeding briefly on the leaves of coconut trees. The feeding site was therefore known.

(a) Transmission Studies

Nymphs and adults of Oncopeltus cingulifer taken from milk-weed plants, Asclepias curassavica, growing in coconut estates were confined to healthy 3-year old coconut palms growing in transmission cages. A closer study of the transmission was undertaken utilizing instead healthy 18-month old seedlings from which the husk (mesocarp and endocarp) of the fruit was removed, leaving the root intact.

Symptoms of the disease, in the young palm, appeared first as necrosis beginning 20-30 days after inoculation feeding. The terminal bud showed putrefaction. Normally, the distal portion of each root was affected by the flagellates located in the phloem and the parenchyma cells of the cortex. The cells eventually broke down. Both older and young roots contained flagellates and bacteria. The flagellates were of the promastigote type with lengths ranging from 18 um to 27 um including flagellum. Twisted forms appeared later in both roots and stem. The migratory milk-weed bugs contained actively swimming promastigotes from 12 um to 16 um in their haemocoel. Similar and also longer forms of over 20 um are seen in the salivary glands.

(b) Artificial inoculation of Phytomonas and Micrococcus in the coconut palm

Whereas materials may be artificially sent up the xylem in the transpiration stream, the pressure in the phloem prevents particles from entering unless they are placed in the way contrived by insect feeders. On the other hand, in the germinating coconut, the haustorium of the seed provides nutrients to the growing plant. Such must travel via large thin walled cells into conducting elements with a central core of 'phloem-like' protoplasm. Thus on injecting a suspension of flagellates and bacteria into the haustorium through the endocarp, the flagellates and bacteria migrated with the food 'current' into the phloem of stem and roots. All plants inoculated with flagellates and bacteria from the milk-weed plant by this method came down with disease showing the identical symptoms. The flagellates and bacteria were recovered.

Flagellates in other insects in the coconut agroecosystem

Dysdercus, mentioned before, contained flagellates of a similar shape and size but on examination these passed out in the eggs to infect the young insects congenitally. Such a flagellate is an insect flagellate and does not require a plant host. No transmission was obtained.

Counts of diseased trees taken throughout Trinidad over a 10-month period revealed about 80% of the cases of Cedros Wilt to be isolated infections. In the others, a cluster of trees was found. In such clusters it becomes necessary for the insect vector to be in the vicinity of the infected tree and to crawl to the crowns of very tall contiguous trees causing pocket infection. The clusters were normally tight.

Of several species of Pentatomidae which are phloem feeders *Mecistorhinus picea* (P. de Beau Vois) which lived and developed on the coconut palm contained the Phytomonads. These insects oviposit on the leaves of the palm and remain with the eggs until they are developed. The juvenile feed on the leaves containing flagellates and bacteria, then crawl to another palm nearby and continue to feed. Giant forms of the flagellates are present in their salivary glands. Transmission trials in the laboratory showed that all the insects utilized were vectors - both nymphs and adults.

The eggs of *Mecistorhinus* sp., are heavily parasitized by the egg-parasite *Phanuropsis semiflaviventris* Giralt (Hym. Scelionideae). The nymphs which escape remain on the sheltered surface of the leaflet and on fallen leaves which carry them to the ground when they continue to develop in humid areas. In such situations their abundance is related to the size of the epidemic. When the parasite takes over, the disease disappears suddenly.

New insect host relations for Phytomonas elmassiani

Phytomonas elmassiani from thé milk- weed has not been modified enough in its relation to the milk-weed and Oncopeltus to hinder its development in a new host. In short, though a new vector is available, continuous re-infection may dilute ecogenotypic variation to new habitat for the coconut flagellate population. The insect, Mecistorhinus sp., represents an enteded host in a new environment of the coconut estates.

Lethal Yellowing Disease -(vector viewpoint)

At present, control programmes for Lethal Yellowing are best approached by resistant varieties despite the slow nature of the process. This is especially so since the industry has practically remained viable by the use of the resistant Malayan dwarfs and the Maypan F. hybrids. Been noted that the other introductions which seemed to have equal resistance were the Ceylon dwarfs, the 'Indian Dwarf' and King Coconut'. Lethal Yellowing resistance of the Malayan dwarf, however, is long lasting.

Present information on the disease indicates very strongly that MLO's are causal to the diseased condition and that Myndus (Haplaxius) crudus is a vector. In 1979, Myndus crudus was shown to transmit a lethal decline to healthy screened Veitchia merrillii, Pritchardia thurstonia and P. remota palms. In July 1980, a Jamaican tall coconut died of Lethal Yellowing in a cage into which large numbers of Myndus crudus were repeatedly introduced over a period of 18 months in experiments at the Agricultural Research Centre in Florida.

Generally, mycoplasma-like organisms have been found consistently within the phloem of palm trees affected with Lethal Yellowing and antibiotic treatment of palms with oxytetracycline has proven effective against these in a well managed injection programme against mycoplasma.

Romney indicated that the search for the vector was hampered by the unavailability at present of an infective extract or culture, that potential vectors were handled in large numbers in the hope that some of them carry LY MLO. The work of Howard utilized large numbers of insects averaging 18,500 per cage taken from LY infected areas. In any event, for commercially grown coconuts current research should attempt to understand the mechanisms of resistance found in the Malayan Dwarfs. Whether there is resistance to the insect vector or resistance to the presence of MLO in the plant should be determined.

Caribbean Distribution of the disease

Overtly, the disease resembles Cedros Wilt in symptomatology, but that's all. Conversely, also it is noted that Red Ring disease is present in most of the other islands where the vector , the palm weevil, is present. Moreover, the relationship of the pathogen to the vector is such that the pathogen does not multiply in the vector. In other words, movement of the diseased plant alone is not a known sufficient condition for the disease to survive in a new environment. It will survive only where suitable vectors to the pathogen are present. In the absence of resistance to the pathogen movement of the infective vector can cause disease in new islands.

Analysis from the Epidemiology of the disease

When the increase of vector related diseases depends on the increase of infectious material, as in Red Ring disease, control measures which remove infedtious material, eventually control the disease and the abundance of insect vectors to the pathogen becomes only secondary in effect. On the other hand, when infectious material plays no initial role in the development of disease, as in Cedros Wilt where the pathogen reaches the coconut from the milk weed plant Asclepias curassavica, then removal of the diseased plant has no function in the epidemic. Rather, removal of the host plant to the insect alone, where the source of infection is found, is functional. The poisoning of Cedros Wilt diseasedtrees therefore will not in principle control the disease as with Red Ring disease. Epidemiological studies from observations made in Jamaica appear to show, in collaboration with the literature, that in outbreak areas of disease primary emphasis on their epidemiological pattern should not be placed on the diseased tree as the source of inoculum to the vector. The explanations are given later on.

Abundance of insects and Abundance of disease

Naturally, 'abundance of insects' as it relates to abundance of disease should be interpreted as 'abundance of infective vectors' which may bear a constant or variable relation in percentage to the actual numbers of the species. In other words, the wide variation in percentage possible for infective individuals, can permit outbreak levels of disease to exist without a significant increase in insect population size overall if the vector species is endemic and vector potential genetically inherited. The source of inoculum and the relationship between the MLO and the vectors seem more likely to be the key features to the transmission of Lethal Yellowing than simple abundance of insects in association with the coconut palm. The relationship sustains whether or not one is dealing with bacterial pathogen, virus pathogen, flagellate pathogen or MLO by extrapolation. Evidence for these can be determined by epidemiological studies in the first instance.

The onset of disease in the field

Often onset of disease begins with a noted single tree or occasionally two, in an area. Generally, a pattern of tree-hopping obtains with (3-4) several trees over a distance of several or a few kilometres showing symptoms simultaneously. The onset of disease in the area may be any of these trees, multiple invasion is not the order where many vectors settle on several trees in close proximity. The second phase of disease may occur 6-12 months later near the infected tree and in some cases as at Sail Rock, Jamaica, 4 new cases occurred in October, 1969 from invasion of a single tree in November, 1968.

Romney reported that in order to attempt control of the disease in isolated outbreaks, the affected tree was poisoned with sodium arsenate and in some cases the trees around were sprayed or injected through the trunk with an insecticide. Despite such efforts the disease was not contained in the outbreak area whereas the sodium arsenate would kill the tree and remove it as a source of inoculum from the epidemic. Later, work with oxytetracycline, though giving remission of symptoms, was not expected to control the spread of disease.

Poisoning of the coconut palm which is diseased is functional in control when the vector is host-specific in its feeding habits and also best when the insect carries on its life cycle on the host. Some species of sucking insect do this, whereas others do not. If the poisoning of diseased trees and the spraying of healthy trees with insecticides do not accomplish some measure of control, then the above mentioned required conditions do not exist.

It would be explained by the migration of insects which develop on another host but also feed on the coconut palm at some time during the adult life since top infection, by the insect hopping, seems to be the rule. Also, in the absence of the diseased coconut tree as a source of inoculum then secondary phase infection (epidemics) would develop from new infected insects in situ. Thus vector insects may produce infective vectors or a collateral host to the pathogen is present in the vicinity.

Transmission of Mycoplasma-like Organisms to plants by arthroped vectors

There is evidence in the literature supporting the ability for mycoplasma-like organisms to multiply in their vectors. Evidence from serial passage can confirm this. Moreover, these organisms have been found by several workers to be associated with cells of the intestine, malpighian tubules, salivary glands, fat-body and even the nervous system. It would appear that mycoplasma can be transmitted repeatedly by one insect vector. This possibility explains the hopping pattern found in Lethal Yellowing. Multiplication in the insect of the pathogen is therefore acceptable.

The question of transovarial transmission is now posed to determine how new vectors might develop in the vicinity of a newly diseased tree when symptoms are seen 6-12 months after. A certain portion of the time being allowed for symptoms to develop on the infected palm and the remainder for the insect to become adult. Answers will only be due to circumstantial evidence and hypothesising at presént. Nevertheless, one vector (fertile adult female) is the fittest to produce a strain of infective adult offspring by tranovarial passage of the mycoplasma.

It is easier to observe vector strains in a new population of non-vectors and then genetic dilution of the mated vector females to the extent that the recessive vector condition in offspring can be genetically obliterated in few generations of vector/non-vector mating causing the disease to subside and vector populations to disappear as a natural condition. The rate at which this transformation occurs depends upon the genetic constitution required by the vector, whether single or multiple allele conditions are needed, and the frequency of random mating if the recessive condition of the vector is not tending to be lethal in the insect/mycoplasma association.

Conditions for Transmission Trials

More than likely, conditions which are present for insect transmission studies are not based on insect survival conditions primarily. Generally, they allow for insects to feed briefly, hoping to transmit the pathogen, then die. Whereas natural conditions for epidemics and confirmed transmission trials should allow for vectors to reproduce when necessary in known ambient and suitable surroundings. Nothing will be wrong scientifically in first preparing living conditions for insects then allowing them to live before introducing the test palms.

The alternate to such a hypothesis would be a weed source of infection in the coconut estates where epidemics are present. The frequency of disease outbreaks can then be accredited to the frequency of certain weeds in the population. In such a case the abundance of migratory insects would be observeable.

A visit to certain estates in the parish of St. Catherine seemed to underscore the fact that weed abundance was more the problem than weed specificity and no where in the literature was the effect of herbicides or different management practices under coconuts a noted measure in the alleviation of the disease outbreak. However, that the vector strain was in fact multiplying in the areas affected, rather than more insects coming in or the positive correlation of abundance of diseased trees with increment of disease, was the case seemed evident from the random cluster of affected trees and the hopping pattern of migration away from the nucleus of the outbreak when seen in the diseased palms at the same stage of pathogenicity away from the infective source.

The nature of the resistance in the Malayan dwarfs would now more than likely be towards the pathogen rather than the vector since the insect coconut palm relation, in itself seem not destructive, thus both vector and non-vector strains may feed therefrom. The emphatic breeding for resistant varieties seem clear, though,now, apparently precariously sited on unknown factors, while yet long lasting.

Finally, if these above conclusions make scientific sense, the observation by Waters and Osbourne concerning the improbability of an occasional palm feeder being able to acquire MLO from such low concentrations of the pathogen in mature fronds of diseased palms, give clearer evidence for a genetically transmitting strain of a vector, in which MLO's multiply and are transovarial in continuity. Moreover, the numbers of such insects are small in any given population, suggesting a lethal condition to the insect. There is no reason why this cannot also impłby a latent condition of mycoplasma in the normal insect and within the correct genetic 'frame', the MLO's are released to multiply significantly in the insect to cause transmission problems to plants on which they feed. This will be in keeping with concepts of the pathosystem from an insect viewpoint.

Symptomatology vs Variety of Coconuts

The tall (typical varieties of coconuts tend to develop pronounced yellowing of the leaves during diseasesassociated with wilting. Finally, there is a browning of the necrotic areas. The shade of yellow is often distinct with the kind of disease and quite characteristic. This also applies to the browning. There is generally an increased darkening, or deepending of the yellow towards brown in the following order: Acute wilting, Red Ring disease, Bronze Leaf Wilt, Cedros Wilt and Lethal Yellowing.

On the other hand, the dwarf (nana) varieties of various types show browning rather than yellowing. Crosses with both types tend to respond to pathogenicity, more or less, as though the variety was purely dwarf of whatever type. In both types, however, the progress of symptoms is in the identical order.

There are occasions when trees show a rapid wilt which is pathogenic but no yellowing or browning occurs. Associated with this is a characteristic broken-leaf status, where the leaves break in the middle of the rachis and eventually hang down. This is normally due to Cedros Wilt di ease.

Xyleborus beetles and disease as vectors of pathogens in Coconuts

Bark beetles are associated with certain symbiotic fungi of the genus

Ceratostomella which causes diseases in bóth temperate and tropical plants. This khowledge, in association with the presence of a wilting syndrome in coconuts and bark beetles - Xyleborus sp., resulted in the opinion that these were causing disease in coconuts in Ecuador. Generally though, Xyleborus sp., visit trees that are debilitated or already infected. Xyleborus has a co-efficient of distribution of almost 1 in coconut paln-tations. It would seem therefore very unlikely that these would be vectors of any pathogen in coconuts. In Jamaica and Seychelles they are regarded as being harmful to trees already unhealthy, whereas, in Fiji they are regarded as a primary pest.

Another disease in which these insects were presumed to be associated is with 'Exudado del Tallo' in Venezuela, which is related to the wound fungus, Ceratosystis paradoxa. The disease formerly called 'necrotis canker' is not widespread and shows a bleeding of the trunk localized near the base. For the reasons already mentioned Xyleborus sp (Sileborus) are not regarded as being important to the transmission of this disease.

The Coconut Mite, Eriophyes Guerreronis, Keifer in the Coconut Groves of Latin America.

The Coconut Mite and the damage caused.

Eriophyoidae mite are generally well adapted plant feeding mites and often tend to cause cosmetic rather than organic damage to plants. The coconut mite causes sometimes complete fruit malformation and stunting, while at other times, produces broken striations of the pericarp which limit fruit development at the particular regions of attack.

The overall proportional composition of the fruit remains the same. However, with limited external size, the meat quantity is reduced proportionally, at least. Therefore, yields of copra per tree can be reduced by whole number factors (sometimes to more than 5 nuts per lb. of copra) to make the farm uneconomic. Moreover, the number of nuts per inflorescence is often reduced by about 30%.

Freitez noted that the first sign to the naked eye of the presence of Eriophyes guerreronis on the young fruits was a whitish powder-like triangular blotch near the calyx on the exocarp. The shape of the blotch may vary from oblong to irregular. These blotches represent colonies of the mite with adults, juveniles and eggs. Eventually, with the growth of the fruit, the colonies advance laterally and mites are protected under the perianth. Occasionally, another species of mite, Tarsonemus sp., is found in association with Eriophyes sp. No damage has been reported by this mite.

The location of the mites under the perianth, which affords them protection, makes it difficult to reach them with chemicals sprayed on the surface of the fruit either from below with mist blowers or above with airplanes. Such is the protection that fallen nuts may contain living mites for several days. The choice of either the utilization of an oil/water emulsion or a systemic acaricide was considered. By drenching the nut with the emulsion it was hoped that oil with its lower surface tension woul seep under the calyx and asphyxiate the mites. On the other hand, a sufficiently potent acaricide might be able to kill the mites if sufficient quantities concentrated under the fruit calyx. The use of the oil/water mixture required equipment which was not readily available at the quantity and the cost required by small farmers.. Biological control measures are at present being studied in Mexico, utilizing a fungus, Hirsutella thompsonii. The need now is for immediate arrest of the mite's demination.

Basically, the minute size and the annulated vermiform body and the unusual feeding appa.atus allows for the successful colonization by these mites. Penetration of the stylets into plant tissue is facilitated by redispositioning of the palpal supports. The mite tends to keep the host alive and apparently does not suck out the entire liquid content of the cell. From all appearances, the injection of the saliva of the mite interacts with auxins of the plant causing fruit malformation. The introduction of a systemic chemical must be made deep enough into the palm to allow for movement around the trunk to all the developing inflorescences or branches.

The use of fungistatic oils, applied for bananas, as a mite inhibitor was also considered since aerial spraying done for bananas which were interplanted among coconuts was thought to be having a delaying effect on population growth of the mite. However, the present alarming increase in status of the mites, in the presence of oils for bananas, indicated their effectiveness only to a point. Thus, such indirect measures could not lead to effective control if even the frequency of spraying was increased in areas where coconuts were present as pure stands. Thus, practically, a systemic acaricide injected into the tree would be a better proposition.

Vamidothion, a phosphorus ester, is the active ingredient in a pesticide preparation. Vamidothion is reported to be active against several species of insects and mites. The preparation is systemic and has given good results in France, England and Germany, against mites which have not developed resistance to organo-phosphorus compounds.

The Development of a Programme for Control in the Island of St. Vincent, West Indies.

Following the preliminary studies done in Trinidad, the full scale operation was planned in two large areas of coconuts affected with mites. The areas were Peter's Hope with large holdings and Vermount with smaller holdings of less than one acre each. Both areas were operated as a 'condon sanitaire' to prevent movement of mites from around. The programme of injection began on 19th April and endéd on 21st May. A total of 3,729 trees were treated. The acreage in Peter's Hope was about 65 acres in one block. Each tree received 100ml of Vamidothion(ULV formulation)in two doses at one week interval. Colour codes were used to indicate the number of treatments. In Peter's Hope the nuts were not removed whereas in the smaller areas in Vermount the old affected nuts were taken off prior to treatment. The areas of Peter's Hope were divided into blocks. (SEE ATTACHED TABLES I, II, III).

Results

After three months the treated trees in Peter's Hope showed about 85% control on the average. That is 85% of the new and existing nuts on the trees were free from the mite damage. In Vermount, where 644 trees were treated on small holdings with the nuts removed, nearly 100% effectiveness was obtained.

Another feature is the increased number of fruit per inflorescence. This feature was generally observed though not statistically checked. However, the increase in abundance of nuts per inflorescence on the treated trees was very obvious.

Conclusion

These preliminary studies indicate the efficacy of a systemic compound Vamidothion on the reduction of the mite population,Eriophyes guerreronis in the coconut groves of St. Vincebt. The primary purpose was to reduce the mite population to such a low level as to determine whether or not environmental factors might be able to keep the mite in check below an economic threshold. The rapid movement of the coconut mite in two years to all areas of the island in itself reveals the inability of the ecosystem to deal with it fully. The principles of the 'condon sanitaire' therefore, was useful to determine redevelopment rates in the areas treated.

Abstract

The coconut mite, Eriophyes guerreronis has become, in two years, a major pest problem of the coconut groves in St. Vincent, W.I. Preliminary studies with the acaricide VAMIDOTHION in Trinidad indicated certain characteristics for efficacious action on the pest. A larger scale test on nearly 4,000 coconut trees in St. Vincent, through injection of 100 ml of the chemical, in two weekly doses of 50 ml revealed above 80% control of the pest when the mature nuts containing mites were not removed prior to treatment and almost 100% control when they were. The absence of the mites resulted in more fruits being borne per inflorescence in treated areas. Such pesticide action is required immediately to curtail the rapid advance of the pest areas in the island of St. Vincent.

TABLE I

ACCUMULATION OF VAMIDOTHION IN NUTS
AFTER INJECTION WITH 50 ML ON ONE
SIDE OF TRUNK (5-8 YEAR OLD PALMS).

Depth of Injection with 50 ml. of Pesticide (Northern Side)	Accumulation of Dye and Pesticide of Circumference of Trunk			
	25%	50%	75%	100%
2" - 4"	2/5 trees	1/5 trees	Not seen	Not seen
4" - 6"	5/5	5/5	4/5	3/5
6" - above	5/5	5/5	5/5	5/5

TABLE II

VARIABLE DOSE OF VAMIDOTHION AND
THEIR EFFECTS ON MITE POPULATION

Amount of Chemical in (ml)	% killed After 14 Days	Comments
50	62	All on young fruit
75	83	All on young fruit and some mature fruit (30 %)
100	94	All on young fruit and some mature fruit (60%)
50) 50) - 100	98	All on young fruit and some mature fruit (65%)

GIVEN IN TWO DOSES.

TABLE III

ACCUMULATION OF VAMIDOTHION IN NUTS
AFTER INJECTION WITH 50 ML ON ONE
SIDE OF TRUNK (5-8 YEAR OLD PALMS).

	% Average Infection before Treatment/ (%Tree Injected in Blocks)	% Infection Controlled after Treatment/ (% Trees Unaffected)		
		1 mth.	2mths.	3 mths
BLOCK A	75	60	75	82
BLOCK B	81	72	81	82
BLOCK C	93	34	82	84
BLOCK D	58	80	86	87

Total No. of trees - 3,085 - Peter's Hope

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APPENDIX I

COMPENDIUM OF INTERCHANGEABLE PESTS WITHIN THE COCONUT AGROECOSYSTEM

Nature of Injury	Order	Name		Distribution
Defoliation	COLEOPTERA	*Archon centaurus*	F.	West Africa
		Barystethus cleutsi		New Guinea
		Dichroa tetradactyla	Burm.	West Indies
		Phyllognathus dionysius	F.	Sri Lanka
	LEPIDOPTERA	*Acanthopsyche cana*	Hamps	Sri Lanka
		A. Lypotenca	Hamps	Sri Lanka
		Artona cartoxantha	Hamps	Indonesia, Malaya, Pacific Is. Phillipines, Thailand
		Brassolis sophorae	L.	Guyana, Trinidad, S.America
		Elymnias fraterna	Butler	Sri Lanka
		Gangara thyrsis	M.	Indo-Malaysian region.
		Hildari irava	Moore	Malaya, Indonesia
		Levuana iridescens	B. Bak	Fiji
		Mahasena corbetti	Tams.	Malaya, Indonesia
		Natada subpectinata (= *N. utichia*	Dyar Schans	Trinidad
		Valanga nigricornis zehneri	Krauss	Indonesia
Defoliation of young palms	COLEOPTERA	*Adoretus celogaster*	Arr.	Sri Lanka
		A. compressus	Web.	Fiji, Malaysia

Nature of Injury	Order	Name		Distribution
	LEPIDOPTERA	Telicota bambusae	Moore	New Guinea
		Thosea cineteomarginata	Banks	Phillipines
Leaf-feeding	COLEOPTERA	Aphanisticus altus	Kerr.	Indonesia
		Brontispa chalybeipennis	Zac	Micronesia
		Exopholis hypoleuca	Wied	Indonesia, Pacific Is.
		Plesispa cacotis	Manlik	New Caledonia
		P. reichei	Chap.	Malaya, Indonesia, Phillipines
	LEPIDOPTERA	Amathusia phidipus	L.	Indonesia, Phillipines, Viet Nam
		A. phidipus var. adustatus	Fruhst.	Thailand
		Psyche albipes	Moore	Sri Lanka
		Nephantis serinopa	Meyr.	India, Sri Lanka, Burma
		Spodoptera manritia	Boisd.	Sri Lanka
		Brassolis astryra	God	Central and South America
		B. isthmia	Bates	Central and South America
	HOMOPTERA	Aleurodicus destructor	Mask.	Indonesia, Malaysia, New Guinea, Phillipines
		Aspidiotus destructor	Sign.	Widespread
		A. destructor rigidus	Reyne	Indonesia
		A. translucens	ckll.	Indonesia
		Cerataphis lataniae	Boisd	Pantropical
		Ceroplastes actiniformis	Green	India, Sri Lanka
		Chionaspis dilatata	Green	Sri Lanka
		Chrysomphalus aonidum	L.	Phillipines
		C. Aurantii	Mask.	Phillipines
		C. Ficus	Ashm	Widespread

Nature of Injury	Order	Name		Distribution
Leaf-feeding	HOMOPTERA	C.Ficus pallens	Green	Indonesia
		Coccus hesperidum	L.	India, Fiji
		C. maniferae	Green	Indonesia, Phillipines
		Ecosac charissa pulchra	Muir	Phillipines
		Fiorinia fiorineae	Targ.	Sri Lanka, Jamaica,New Caledonia, Phillipines
		Ischnaspis longirostris	Sign	Sri Lanka, Seychelles, Papua New Guinea, Malaysia
		Lecanium acutissimum	Green	Sri Lanka
		L. Tessellatum	Green	Sri Lanka
		Lepidosaphes mcgregori	Banks	Phillipines, Micronesia
		L. Unicolor	Banks	Phillipines, Micronesia
		Paralecanium expansum Quadratum	Green	Phillipines, Micronesia
		Phenacaspis inday	Banks	Phillipines, Micronesia
		Phyrrhoneura maculata	Muir	Phillipines, Micronesia
		Planococcus citri	(Risso)	Sri Lanka, Fiji, Solomons
		Psendaonidra trilobitiformis	Green	Sri Lanka, Seychelles
		Psendocococus longispinus	Targ	India, Sri Lanka
		P. Nipae	(Mask)	U.S.A., Viet Nam
		Psendococus sp.		Indonesia
		Comstockiella sabalis	Comst.	Bermuda

Nature of Injury	Order	Name		Distribution
	ORTHOPTERA	Valanga nigricornis	Burm.	Malaysia
		V. nigricornis sumatrensis	Uv.	Indonesia
		V. Transiens	Walk.	Indonesia
Feeding on unopened Leaves	COLEOPTERA	Brontispa forggatti	Sharp.	Indonesia, Phillipines
		B. limbata	Waterh.	Mauritius
		B. Mariana	Speath	Pacific Is.
		B. palauensis		Micronesia
		B. selebensis	Gestro	Indonesia
		B. simmondsi	Mlk.	New Guinea
		B.Yoshinol		Micronesia
		Oryctes gnu	Mohn	Indonesia, Malaya,Thailand
		O. monoceros	Ol.	Madagascar,Seychelles, E.& W. Africa.
		O.rhinoceros	L.	Widespread
		Scapanes australis	Boisd.	New Guinea Phillipines
		Wallaceana palmarum	Gestro	Indonesia
		Xylotrupes gideon	L.	Malaya, India, Indonesia, New Guinea,Phillipines, Solomons.
Feeding on young leaves	COLEOPTERA	Botryonopa sanquinea	Guer	Indonesia
		Diocalandra frumenti	F.	Sri Lanka, India, Indonesia Phillipines, Zanzibar, Pacific Is.

Nature of Injury	Order	Name		Distribution
	ORTHOPTERA	Cardiodactylus Novae guineae	Haan	Solomon, Papua- New Guinea
Feeding on young leaves	HETEROPTERA	Assamia moesta Stephanitis typicus	West. Dist	Sri Lanka India
Attacking bud	COLEOPTERA	Chalcosoma atlas	L.	Phillipines, New Guinea
Leaf-mining	COLEOPTERA	Promecotheca coerulei-pennis	Blanch.	Pacific Is.
		P. cumigu	Baly	Phillipines, Borneo, Malaya
		P. opacicollis	Gestro	Pacific Is.
		P. reichei	Baly	Pacific Is.
		P. papuana	Csiki	New Guinea
		P. soror	Maul.	Indonesia
Leaf-rotting	LEPIDOPTERA	Erionota thraz	L.	Indo-Malaysian region
Leaf-spinning	LEPIDOPTERA	Gangara panda	Moore	Indonesia
Feeding on under-surface of leaves	HOMOPTERA	Aleurodicus cocois	Curtis	West Indies.
Inducing development of sooty mould	OMOPTERA	Eucalymnatus tessellatus	Sign	Seychelles, Fiji, New Caledonia

Nature of Injury	Order	Name		Distribution
Tunnels petioles	COLEOPTERA	Diocalandra stigmaticollis	Gyll.	India
	LEPIDOPTERA	Trachycentra calamias	Meyr.	Fiji
		Castnia daedalus	Cram.	Guyana
Larvae injuring young shoots	COLEOPTERA	Prot o:erius colossus	F.	Indone ia
		P. praetor	F.	Indonesia
	LEPIDOPTERA	Chalcocelis albiguttata	Snell	Malaya,Indonsie,Viet Nam
		C. Fumifera	Swinh.	Malaya Burma
		Contheyla rotunda	H.	India
		Darna catenatus	Snell.	Indonesia
		D. Trima	Moore	Indonesia, Malaysia
		Haemolytis miniana	Meyr.	Indonesia
		Narosa Conspersa	Walk.	Indonesia, Sri Lanka, India, Taiwan
		Parasa Lepida	Cram	Indo-Malayan region
		Ploneta diducta	Snell.	Indonesia
		Setora nitens	Walk.	Malaya, Indonesia, Viet Nam
		Thosea aperiens	Walk	Sri Lanka
		T. Loesa	Moore	Thailand
		T. molluccana	Rpk.	Indonesia
		T. sinensis	Walk	Indonesia
		Trichogyia albistrigella	Sn.	Indonesia, Thailand.
Larvae boring into soft stem	COLEOPTERA	Diocalandra taitensis	Guerin	Pacific Is.

Nature of Injury	Order	Name		Distribution
Larvae boring into soft stem	COLEOPTERA	Metamasius homipterus	L.	American tropics
		Polyderces zonatus	Swed.	West Indies
		Rhabdocnemis maculatus	Syl	Sri Lanka
		Dynamis politus	Gyll	Brazil, Guyana
Boring into woody parts	COLEOPTERA	Melittomma insulare	Fairm.	Seychelles,Madagascar
		Panglyphyra woodlarkiana	Montr	Indonesia
		Rhabdocnemis lineaticollis	Hell	Phillipines
		Rhynchophorus ferrugineus	F.	India, Sri Lanka,Phillipines Burma, Indonesia, Thailand, Viet Nam.
		R. kaupi	Schauf	New Guinea
		R. palmarum	L.	American Tropics
		R. papuanus	Kirsch	New Guinea
		R. phoenicis	F.	West Africa
		R. schach	Oliv.	Malaya, Phillipines, Indonesia Thailand, Pacific Is.
		Xyleborus perforans	Woll.	Seychelles, West Indies, Sri Lanka, Tropical America.
		Rhinostomus barbirostris	F.	Tropical America.
	ISOPTERA	Coptotermes ceylonicus	Holmgr.	Sri Lanka
	HYMENOPTERA	Dorylus orientalis	Westw.	India, Burma, Sri Lanka, Pakistan
Feeding on flowers	COLEOPTERA	Eurytrachelus egregius	Moll.	New Guinea

Nature of Injury	Order	Name		Distribution
Feeding on flowers	COLEOPTERA	Eurytrachelus sp.		Indonesia
		Nodocnemis uniformis (Larvae)	Mshl	Solomons
		Odontolabis bellicosus	Cast.	Indonesia
9 (i) Male flower		Poecilopharis emilia	White	New Guinea,New Herbrides
	LEPIDOPTERA	Coconympha iridarcha	M	India
		Coleoneura trichogramma	Meyr	Fiji, Tonga
		Lamoria sp.		Zanzibar
		Tiratheba rufirena	Walk	Malaya, New Guinea, Indonesia Solomons, Thailand,New Caledonia
		Myalospila ptychis (Larvae)	Dyar	Brazil
	HYMENOPTERA	Polyrachis schistacea (rar.regulosa and mulitaris)		Zanzibar
Damage to inflores-cence	COLEOPTERA	Homalinotus coriacens	Gyll	Brazil, Argentina
	LEPIDOPTERA	Acritocera negligens	Butler	Malaya, Fiji
		Batrachedra arenosella	Walk	India, Indonesia (?) Malaya
	HETEROPTERA	Amblypelta cocophaga	China	Solomons
		Axiagastus cambelli	Dist.	Solomons, New Herbrides, New Guinea
		Pseudotheraptus wayi	Br.	Zanzibar
Attacking nuts	COLEOPTERA	Pachymerus lacerdae	Chevr.	West Africa

Nature of Injury	Order	Name		Distribution
Attacking nuts	LEPIDOPTERA	Tirathaba rufivena	Walk	Malaya, New Guinea, Indonesia, Solomons, Thailand, New Caledonia
		Harpagoneura complexa	Btlr	Fiji, Brazil
		Phostria blackburni	Btlr	Hawaii
		Stathmopoda mucivora	Meyr.	Solomons
Larvae attacking roots	COLEOPTERA	Lepidiota stigma	F.	Indonesia
		Lepidoderma pica	Arr	Indonesia
	ISOPTERA	Coptotermes ceylonicus	Holgmr.	Sri Lanka
Root-feeding	COLEOPTERA	Lenchopholis corneophora	Surm	India
(i) Injury to seedlings	ISOPTERA	Odontotermes obesus	Ramb.	India
	HYMENOPTERA	Dorylus orientalis	Westw.	India, Burma, Sri Lanka, Pakistan
(ii) Injury to seed-lings underground	COLEOPTERA	Strategus aloecus	L.	West Indies
		S. anachoreta	L	West Indies
		S. titanus	L	West Indies
Fosters noxious Coccids	HYMENOPTERA	Oecophylla smaragdina	F	Indo-Australian region
Borer	LEPIDOPTERA	Castnia licus	Drury	Central and South America

A P P E N D I X II

PEST	CONTROL MEASURES	LOCATION
Agonoxena argaula	Young palms should be treated with an aqueous preparation of malathion at about).3 - 0.4%. Fertilizers drainage and control of weeds help to reduce the drainage done to the trees. Several indigenous parasites attack the insect in Fiji; those attacking the caterpillar belong to the genera Apanteles, Bracon and Agathis and Tongamyia. A parasite attacking the chrysalis belongs to Brachymeria. In Fiji, these have been reinforced by the introduction of Elachertus agonoxenae, Kerrich from New Guinea and a tachinid, Actia painei, Crosskey, from New Britain. These introduced parasites attack the caterpillars and the average total level of parasitization by them is F1%, of which about half is due to Apantèles. Brachymeria destroys 35% of the chrysalides, the total mortality of which is 51%.	New Hebrides, Fiji, Polynesia, Ellice Is. Guam. Hawaii, Palmyra
Amblypelta cocophaga	The best results have been obtained with dieldrin, Solomon Is. through endrin in the same conditions had the most rapid initial action. Aerial spraying is uneconomic (Fenemore, 1958) and the use of ground-operated equipment is not economic or practical since the average height of the trees is 20-25 meters in long-established plantations. The predatory ant, Oecophylla smaragdina Fabricius, is a very effective limiting factor when undisturbed by two other species of ants, notably Pheidole megacephala Fabricius. Attempts have been made to control Amphypeita by adjusting the conditions in the plantions so as to favor Oecophylla at the expense of Pheidole and other ant species.	

PEST	CONTROL MEASURES	LOCATION
Brontispa longissima	Infested trees are sprayed every 4-6 weeks with a solution of 0.15% dieldrin by means of low-volume Knapsack sprayers. Good results have also been obtained with DDT at 0.2% and Chlordane at 0.16% but these products are less persistent than dieldrin. Tetrastichus brontispae Ferr, is the most effective parasite of the larvae and pupae.	Indonesia, Moluccas, New Guinea, Solomon, New Hebrides, New Caledonia, Tahiti.
Castnia daedalus	Spraying with a 5% solution of dieldrin at 4-5 litres per tree is recommended.	The Guianas, the Amazon basin and Panama
C. licus	Dieldrin at 1% in solution applied at 2.5 litres per tree is effective	Central and South America and Trinidad
Diocalandra stigmaticollis (- D. frumenti)	Treatments generally adopted are painting with tar the wounds made by the insects and earthing up the bases of the trunks	New Guinea, Solomons, Malanesia, Polynesia, Hawaii, Madagascar
Graeffea crouani	Application from the air of a spray of 0.5% gamma-BHC in oil at about 28 litres per hectare alternatively, a 50% BHC dispersible powder can be applied at about 11 kg per hectare. Treatments should be repeated every 4 months.	New Hebrides, New Caledonia, Fiji, Samoa, Tonja, Wallis Is.
	In addition to two indigenous parasites of the eggs, both belonging to the genus Paranastatus, the ant Tapinoma melanocephalum Fab. contributes to the destruction of the eggs.	Kerala in South India
Leucopholis coneophora	Dusting the soil with about 66 kg of 10% BHC or 33 kg of 5% chlordane per hectare and then plowing to a depth of 15 cm is recommended for	

PEST	CONTROL MEASURES	LOCATION
	destruction of the early stages (Menon and Pandelai, 1958). Aldrin,dieldrin,heptachlor and malathion are also effective and for protecting the germinating nuts in nursery beds.	
Aspidiotus destructor	The waxy scale which covers the insect makes control by insecticides difficult. However, good results have been obtained in Fiji on young palms sprayed with malathion at 0.1% or diazinon at 0.25% (Hinckley, 1961).DDT is not recommended. In Trinidad,similarly satisfactory results were obtained with parathion,malathion and dieldrin. In at least 5 groups of islands, successful biological control has been achieved by the introduction of predacious ladybird beetles (Coccinellidae). These include Cryptognatha nodiceps. Marshall from Trinidad Chilocorus nigritus Fabricus, from Ceylon and Chilocorus Mulsant from Java	Almost tropicopolitan
Axiagastus cambelli	Spraying with DDT or with a wettable powder of 50% dieldrin is recommended. Two parasites of the eggs are known: Anastatus axiagastii Ferriere and Microphanurus painei Ferriere.	Solomon Is. New Hebrides, New Guinea, Bismark Archipelago
Azteca cartiflex	Application of a 30- cm band of 15-20% dieldrin round the trunk about a meter above ground level, using about 0.3 litre per tree is said to prevent the ants from having access to the tree for one to two months.	

PEST	CONTROL MEASURES	LOCATION
Brassolis sophorae	In Guyana, good results have been obtained by spraying with 0.5% dieldrin and in Brazil the application of 2% BHC dust every 20-25 days in tall trees is recommended. Treatment with DDT as either dust or spray proved satisfactory in Surinam. The eggs of B. sophorae are parasitized by species of Telenomus and Anastatus; the caterpillars by Winthemia pinguis Fabricus; and the pupae by two species of Brachymeria and by Spilochalis morleyi Ashmeed.	Tropical South America, Trinidad.
Nephantis serinopa	Sprays of DDT at 0.2% gives a 80% reduction of caterpillars in two weeks, but the persistence of the insecticide, of about two weeks, was prejudicial to the beneficial parasite Trichospilus pupivora Ferr. which attacks the chrysalis.	Ceylon, Southern India, Burma
Ophicrania leveri	In Guadalcanal and New Georgia, this insect is parasitized by a tachinid fly which is attaining a 35% parasitization.	Solomon Is.
Oryctes species	All possible breeding places must be eliminated and every effort must be made to ensure that no new ones are created. Where plant material is used for making compost, chemical treatment of it is necessary to prevent the breeding of the beetle in it. 0.001% gamma-BHC and 0.01% aldrin are effective. Drazinon at 32% is costly but is more rapid in action and has longer persistence.	S.E. Asia, Phillipines and Southern China, Fiji, New Guinea, Wallis Is.

PEST	CONTROL MEASURES	LOCATION
	Biological control has been attempted using the fungus Metarrhizium anisopliae and the insect parasites of Oryctes larvae belonging to the family Scoliidae as well as species of predatory beetles including Catascopus, Neochryopus and Mecopus.	
Promecotheca opacicollis	Chemical control should be used only in the absence of parasites. The parasite Oligosita utilis destroys up to 40% of the eggs.	New Hebrides and Solomon Is.
P. papuana	In New Britain, Pediobius parvulus was entirely successful. Several other parasites exist, the most important being an egg parasite. Closterocerus splendens Kowlaski and the larval parasites Apleurotropis lalori Girault and Eurytoma promecothecae Ferriere.	New Guinea, Bismark Arch.
Pseudotheraptus wayi	Dusting with 0.4% gamma-BHC at about 22.5 kg per hectare gives good results but it destroys the beneficial predatory ant Oecophylla longinoda Latreille and should never be used where this ant occurs.	Coastal zones of Tanzania and Kenya and Zanzibar.
Rhabdoscelus obscurus	In New Guinea this pest is kept in check to a considerable extent by the parasite Ceromasis sphenophori (Tachinidae) which has been introduced into Hawaii and other countries for control of the weevil. The results have been good.	Moluccas, New Guinea, Pacific Is. (including Hawaii), Queensland (Aust.), Celebes, Java, Sumatra, Boneo
Rhinostomus barbirostris	Treatment of the trees with a solution of 5% dieldrin or with pyrethrum and piperonyl - butoxyl at a similar concentration is recommended.	Mexico, South America, Trinidad

PEST	CONTROL MEASURES	LOCATION
Rhadinaphelenchus cocophilus	Strict estate hygiene, particularly poisoning and burning infected trunks is essential to eliminate the vector Rhynchophorus.	Honduras, Panama, Brazil, Venez. Colombia, Trinidad & Tobago, Grenada, St. Vincent.
Rhynchophorus ferrugineus R. schach	Dieldrin at 0.1% should be applied to damaged trunks or, in the case of new plantings sprayed every 3 months on the crowns and bases of trees. Another method is pouring diluted Metasystox into a hole about 5 cm deep drilled in the truck just above the injury.	India, Sri Lanka, Thailand New Guinea, Phillipines
	Since most of the damage done by Rhynchophorus is secondary to that of Oryctes, control of the latter is important. This requires destruction by burning of Oryctes breeding places. It is also necessary to avoid injuring the trees, thus providing sites for egg laying by the weevil. In south India, prophylactic control is obtained by placing 225 gms. of BHC powder or 5% chlordane, mixed with an equal volume of sand in the leaf-axils.	India, Sri Lanka, Thailand, New Guinea, Phillipines.
R. palmarum	Guard baskets, containing chunks of diseased tissue soaked in 0.1% Lannate at the rate of 1 gallon per basket, should be placed 1 per acre throughout the estate. These baskets remain active for about 10 days to 3 weeks. Insects visiting these baskets are killed within minutes. Guard baskets function practically as the deterring diseased tree in an estate.	Tropical S. America, Mexico West Indies.

PEST	CONTROL MEASURES	LOCATION
	A solution in water of 0.1% Lannate, sprayed in the leaf axils of diseased trees kills all the insects present. The recommended dosage is 1 gallon per tree. When trees with broken necks are chopped and soaked with 0.1% Lannate, the larvae, pupae and adult insects as well as nematodes are killed. The insecticide does not mask the attractiveness of the diseased tree to visiting insects.	
Stephanitis typicus	Application of malathion at 0.1% in an emulsifiable solution, or of diazinon or parathion at the same concentration, is recommended.	S. China, Taiwan, Korea, S. India, Phillipines, Pakistan, Sri Lanka, Malay. Peninsula, Indonesia, New Guinea.
Strategus aloeus	Good estate sanitation is an essential control measure since the larvae live in old palm trunks and other dead vegetable matter. Control by applying a ring of chlordane or aldrin at a distance of 0.5 metre from the base of the trunk has been suggested (Dinther, 1956) or 2.5% heptachlor at 300 gms. per palm in the first year increased to 300-600 gms. subsequently (Vayssiere, 1965).	
Tirathaba rufivena	Wyniger (1962) suggests treatment with a dieldrin wettable powder as soon as the first damage appears on the spadix. The most important parasites of T. Rufivena in Malaysia are Devorgilla palmaris and Apanteles tirathabae, both of which have been introduced to Fiji to combat T. complexa.	Sri Lanka, Malay Peninsula, Borneo Indonesia, New Guinea, Queensland (Aust.) Solomon Is. New Hebrides, New Caledonia.

A P P E N D I X III

THE MOST COMMON FUNGI ASSOCIATED WITH THE COCONUT PALMS IN LATIN AMERICA

Country	Name of Fungus	Associated Disease or Plant Organ host	References
BRAZIL	*Botryodiplodia theobromae*	Leaf Blight	RADHA K. (1978) Report of plant pathologist, Central Plantation Crops Research Institute,Regional Station,Kayangualam, Kinshnapuram-690, 533, Kerala, India, to Brazil in June, July 1978. 16 pp.
	Catacauma torendiella	Unspecified	BATISTA A.C. (1946) Principal plant diseases in the North-East Bol.Agric. Pernambuco 13 (4):195-252.
	Cylindrocladium sp.	Peduncle Rot	-do-
	Fomes lamoaensis	Unspecified	BONDAR G. (1940) Noxius insects and diseases of the coconut (*Cocos nucifera*) in Brazil. Bol. Inst. Centr. Forns. Econ. Bahia 8; 160 pp.
	Fusarium sp.	Top Rot	BATISTA A.C. AND COELHO M. (1947) Investigations on the control of dumping-off of dwarf coconut seedlings. Bol. Agric. Pernambuco 14 (4): 297-316.
	Marasmius palmivorus	Unspecified	BONDAR G. (1940) Noxius insects and diseases of the coconut (*Cocos nucifera*) in Brazil. Bol. Inst. Centr. Farns.Econ. Bahia 8: 160 pp.
	Pestalotia palmarum	Leaf Blight	RADHA K. (1978) Report of plant pathologist, Central Plantation Crops Research Institute, Regional Station, Kayanghlam, Kishnapuran- 690,533,Kerala, India, to Brazil in June, July 1978. 16 pp.

Country	Name of Fungus	Associated Diseases or Plant Organ host	References
BRAZIL	*Phyllachora sp.*	Leaf Blight	JOHNSON (1965) Host list of fungi etc. and insects record in the South East Asia and Pacific Region. *Cocos nucifera* L. Coconut Tech, Dept. No. 16: 18 pp. FAO Regional Office. Bangkok, Thailand.
	Phyllosticta palmicola	Unspecified	BATISTA A.C. (1952) and VITA A.F. (1952) Monograph of the species of *Phyllosticta* Pernambuco Bol.(Agric. Pernambuco 19 : (1- 2) 1-80.
	Phyllosticatina cocoicola	Unspecified	BATISTA A.C. (1952) Some new specied of *Phyllostica* and *Phyllosticatina*. Bol. Agric. Pernambuco 19: (3-4): 212-215.
	Phytophthora palmivora	Unspecified	BONDAR R. (1940) Noxius insects and diseases of the coconut (*Cocos nucifera*) in Brazil. Bol. Inst. Centr. Forns.Econ. Bahia 8: 160 pp.
	Phytophthora sp.	Leaf Blight	RADHA K. (1978) Report of plant pathologist, Central Planation Crops Research Institute, Regional Station, Kayangualam, Kinshnapawan - 690,533, Kerala, India, to Brazil in June,July 1978. 16 pp.
	Rhizoctonia bataticola (*Macrophomina pluseoli*)	Unspecified	BONDAR R. (1940) Noxius insects and diseases of the coconut (*Cocos nucifera*) in Brazil. Bol. Inst. Centr. Forns. Econ, Bahia, 8: 160 pp.
	Thielariopsis (*Ceratostomella paradoxa*)	Unspecified	-do-

Country	Name of Fungus	Associated Disease or Plant Organ host	References
CAYMEN IS.	Phytophthora palmivora	Bud Rot	EDWARDS W.H. (1938) Report on the agricultural survey in Cayman Islands with notes on more pests and diseases which were found attacking economic plants in the Dependency of Jamaica. Bull. Dept. Sci. Agric.Jamaica (N.S.) 13: 40 pp
COLOMBIA	Aspergillus sp.	Blue Stain of Trunk	SANCHEZ POTES A (1966) Diseases of cotton, coconut and oil palm in Columbia . Act. Agron. Palmira 16:1-3.
	Ceratostomella paradoxa	Gummosis	SANCHEZ POTES A. (1966) Disease of cotton, coconut and oil palm in Columbia. Act. Agron. Palmira 16: 1-3.
	Capnodium sp.	On withered Leaf	TORO R.A. (1930) Colombia,Republic of)Crop diseases and pest. Int. Bull. PL. Prot. 4 (1):3-4.
	Penicillium sp	Blue Stain of Trunk	SANCHEZ POTES A. (1966) Disease of cotton, coconut and oil palm in Columbia. Act. Agron. Palmira 16: 1-3.
	Pestalotia palmarum	Leaf Mildew	- do -
	Phoma sp.	Leaf Break	- do -
	Phytophthora palmivora	Fruit Rot	- do -
	Phytophthora palmivora	Shoot Dessication	- do -
	Phytophthora palmivora	On Withered Leaf	TORO R.A. (1930) Columbia (Republic of) Crop diseases and pests. Int. Bull. Pl. Prot. 4(i): 3-4.
	Rhizoctonis sp.	On Roots	- do -

Country	Name of Fungus	Associated Disease or Plant Organ host	References
CUBA	Alternaria sp.	Heart Rot	TODOROVA MIJAILOVA,PARASKEVA (1967) Report on heart rot of coconut palm. Revta. Agric. Havana. 1: 74-110.
	Ascochyta sp.	- do -	- do -
	Cladosporium sp.	- do -	- do -
	Clasterosporium sp.	- do -	- do -
	Curvularia sp.	- do -	- do -
	Dactylaria sp.	- do -	- do -
	Diplodia sp.	- do -	- do -
	Fusarium sp.	- do -	- do -
	Cloeosporium sp	- do -	- do -
	Pestalotia sp	- do -	- do -
	Phoma sp	- do -	- do -
	Phytophthora palmivora	Bud Rot	BURNER S.C. (1922) The death of coconut trees Rev. Agric. Com. y. Trah (Cuba) a: 9-10.
	Phythium sp.	Heart Rot	TODOROVA-MIJAILORA, FARASKEVA (1967) Report on heart rot of coconut palm. Revta. Agric. Habana 1: 74-100.

Country	Name of Fungus	Associated Disease or Plant Organ host	References
CUBA	*Stemphylium sp.*	Heart Rot	TODOROVA MIJAILORA, PARASKEVA (1967) Report on hear rot of coconut palm Revta. Agric. Habana. 1: 74-100.
	Trichoderma sp.	-do -	- do -
	Verticillum sp.	- do -	- do -
DOMINICAN REPUBLIC	*Ceratostomella paradoxa*	Stem Bleeding	SCHIEBER E. (1970) Important diseases of the coconut palm in the Dominican Republic, Turvialba 20: 171-176.
	Phytophthora palmivora	Bud Rot	- do -
ECUADOR	*Phytophthora palmissa*		
	Ceratotstomella paradoxa		
GUYANA	*Pestalotia palmarium*	Leaf Blight	COPELAND E.B. (1921) The Coconut. 224 pp. Mac Millan and Co. Ltd. London.
JAMAICA	*Diplodia sp.*	Premature death	SMITH F.E. (1929) Plant disease in Jamaica in 1928. Report of the Government Mycrologist. Ann. Rept. Agric. Jamaica for the year end 31st December, 1928: 17-20.
	Phytophthora palmivora	Premature death	S -do-
	hythium sp.	Dieback of Roots	ASHBY S.F. (1921) Report of the Microbiologist, 1920. Ann Rept. Agric. Jamaica for 1920: 24-25.

Country	Name of Fungus	Associated Disease or Plant Organ host.	References
JAMAICA	Phytophthora palmivora	Bud Rot	ASHBY S.F. (1922) Oospores in cultures of Phythophthera faberi. Kew. Bull. Misc. Inform. 9:257-262.
	Rhizoctonia sp.	Dieback of Roots	ASHBY S.F. (1921) Report of the Microbiologist, 1920. Ann. Rept. Agric. Jamaica for 1920:24-25.
	Thielaviopsis sp.	Bitten Leaf	BAIN F.M. (1940) Report on the coconut growing areas of Jamaica Bull. Dept. Sci. Agric. Jamaica (N.S.) 22: 12 pp.
PUERTO RICO	Phytophthora palmivora	Bud Rot	TUCKER C.M. (1924) Controlling bud rot. Agricultural notes. Puerto Rico. Ecper. Stat.Mayaguez 8: 1 p.
	Thielaviopsis paradoxa	Premature fall of nuts and leaves	COOK M.I. (1924) Coconut fall. (Preliminary paper) J. Dept.Agric. Puerto Rico 8 (4): 12-14.
TRINIDAD AND TOBAGO	Ceratostomella paradoxa	Stem Bleeding	GOBERDHAN L.C.(1961) Coconut disease in Trinidad and Tobago. I. Bleeding stem. J. Agric. Soc. Trinidad and Tobago. 61; 33-38.
	Phytophthora palmivora	Bitten Leaf	STELL (1920) Plant Pathology,Admin.Rept. Dept. Agric. Trinidad and Tobago for the year 1927: 33-36.
VENEZUELA	Ceratostomella paradoxa	Bleeding Stem	
	Phytophthora palmivora	Bud Rot	MORALES F. Generalides sobre Enfermedades en Coco - Fusagri y Foncopal,Venezuelà.

APPENDIX IV

THE MOST COMMON INSECTS ASSOCIATED WITH THE COCONUT PALMS IN LATIN AMERICA

Country	Order	Name	Nature of Injury
AMERICAN TROPICS	Coleoptera	*Metamasius hemipterus* L.	Larvae live in soft parts of the tree. Palms often fatally injured.
	- do -	*Rhyncophorus palmarum* L.	Larvae burrowing into wood or stem or leafbases.
	- do -	*Rhinostamus barbirostris* F.	Larvae burrow in trunk.
	- do -	*Xyleborus perforans* Wall	Boring into woody parts
BRAZIL	- do -	*Homalinotus coriaceus* Gyll.	Feed on spathe and rachis
	- do -	*Brevicolaspis villosa* Bryant	Adult eat foliage
	- do -	*Delocrania cossyphoides* Guer.	Leaf eating
	- do -	*Dynamis politus* Gyll	Larvae burrow in top of stem
	- do -	*Mecistomela marginata* Latr.	Eats young fronds
	- do -	*Mecistomela quadrimaculata* Guer.	Eats young fronds
WEST INDIES	- do -	*Oichroa tetradactule* Burm.	Defoliation
	- do -	*Polyderces zonatus* Swed.	Larvae in soft parts of the tree; palms often fatally injured before the pest is rejected
	- do -	*Rhina barbirostris* (F)	
	- do -	*Strategus titanus* L.	Attack seedlings under ground
	- do -	*Strategus aloeus* L.	- do -
	- do -	*Strategus anachoreta* L	- do -

Country	Order	Name	Nature of Injury
WIDESPREAD	Coleoptera	Oryctes rhinoceros L.	Feeding on unopened leaves
BRAZIL	Lepidoptera	Brassolis astryra God.	Leaf eating
	- do -	Hyalospila ptychis Dyar	Larvae feed on flowers
	- do -	Aleuronudus induratus Hemp.	
	- do -	Ceraleurodicus splendidus Hemp.	
	- do -	Harpagoneura complexa Btir	Attacking nuts
BRITISH GUIANA TRINIDAD SOUTH AMERICA	- do -	Brassolis sophorae L	Defoliation; loss of crop and death of palms in wet seasons
BRITISH GUIANA	- do -	Castnia daedalus Cram.	Excavating tunnels between the trunk and the bases of the fronds.
CENTRAL & SOUTH AMERICA	- do -	Brassolis astryra God	Leaf feeding
	- do -	Brassolis isthmia Bates	Leaf feeding
	- do -	Castnia licus Drury	Borer
FLORIDA, JAMAICA	- do -	Oiketicus abbotti Grote	
TRINIDAD	- do -	Natada subpectinata Dyar (-N. urichia Schaus)	Defoliation
BERMUDA	Hemiptera/Homoptera	Constockiella sabalus Comst.	Leaf feeding
WEST INDIES	- do -	Aleurodicus cocois Curtis	Feeding on undersurface of leaves
BRITISH GUIANA	Orthoptera	Tropidacris latreillei Perty	Defoliation

PEST	CONTROL MEASURES	LOCATION
Coconut Mite *Eriophyes (Aceria) guerreronis*	Preliminary studies with the acaricide VAMINDOTHION - 'Kilval' (R) in Trinidad indicated certain characteristics for efficacious action on the pest. A larger scale test on nearly 4,000 coconut trees in St. Vincent, through injection of 100 ml of the chemical, in two weekly doses of 50 ml revealed above 80% control of the pest when the mature nuts containing mites were not removed prior to treatment and almost 100% control when they were. The absence of the mites resulted in more fruits being borne per inflorescence in treated areas. Such pesticide action is required immediately to curtail the rapid advance of the pest areas in the island of St. Vincent.	West Indies; Trinidad, and Tobago, St. Vincent, Grenada, St. Lucia, Jamaica, Latin America: Venezuela, Mexico, Guyana, Colombia.

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A SIMPLE KEY FOR THE CLASSIFICATION AND DISEASES WITH SYMPTOMS OF WILT

Some common diseases of the coconut palm in Tropical America with symptoms of wilt are:-

1. Red Ring disease
2. Bronze Wilt
3. Lethal Yellowing disease
4. Bud-rot disease
5. Acute wilt
6. Cedros wilt.

Easy classification for Identification in the field

1. (a) Leaves with bright yellowing beginning from the apex of the leaf either near the rachis or at the tip of the leaflets .... 2.

(b) Wilt symptoms present but leaves show no yellow discoloration .... 6.

2. (a) Yellowing and death of the young leaves only; the center leaves of the crown can be pulled out easily. There is putrefaction of the bud (BUD ROT).

(b) Yellowing of the leaves in order of age round the tree, progressing slowly and beginning with the lowest leaves .... 3.

3. (a) Rapid yellowing; bronze discoloration rather than just yellowing; the trees do not die. Many trees are affected simultaneously in one block (BRONZE LEAF WILT).

(b) All the leaves turn yellow more or less rapidly, colouration, however, is always progressive.

4/ (a) Discoloration normally present in all the leaves present on the tree. These persist and turn brown before dyimgg (RED RING).

(b) The yellow discoloration is completed in all lower leaves, but the crown leaves remain green until death.

5. (a) Identification in any isolated palm or pairs of palms, or small groups of palms isolated among healthy trees (CEDROS WILT).

(b) Affected trees die in 5 months on the average. Symptoms similar to 5 (a), but the yellow discoloration more orange than yellow. Diseased trees at similar stage of pathogenesis close by (LETHAL YELLOWING).

6. (a) Very rapid yellowing of the leaves which sometimes break at the center. Later, the brown leaves can be pulled out. easily: Cedros isolated trees. (CEDROS WILT).

(B) Slow or rapid yellowing of the young plants, principally in the dwarfs when conditions are dry, not fatal (ACUTE WILT).