SURVEY OF THE CITRUS PESTS
OF TRINIDAD.

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I. INTRODUCTION.

1. GENERAL:

The first large-scale plantings of citrus in Trinidad were those of grapefruit and oranges which took place during the nineteen-twenties. They were largely stimulated by the failure of cacao due to witches broom disease coinciding with low prices for that crop and rendering it uneconomic. The Trinidad citrus industry, which depends today mainly on grapefruit, is thus relatively new; but it has made and is making rapid growth, being now third in importance among the agricultural exports of the island, ranking in value behind only sugar and cacao. The export of citrus fruits and their products realised over $2 million in 1948, and nearly $3 million in 1950.

Much of this increase is due to expansion of the area planted in citrus through the impetus received from funds made available under the Cacao Subsidy Scheme for replacement of cacao in unsuitable areas by other crops. The increase in acreage under citrus is reflected by the records of the Citrus Growers' Cooperative, to which the great majority of citrus growers in the island belong. In 1947 the combined acreage registered with that organisation was 3015.74 acres of grapefruit and 1843.45 acres of oranges. This represented 228,815 grapefruit and 230,130 orange trees in full bearing, and though no final figures are available for years since then, it is expected that these numbers will have been greatly increased by more and more young trees coming into full bearing annually.

The humid climate of Trinidad seems favourable to the development of citrus, particularly...
in so far as growth and yield are related to the prevalence of pests. As will be seen later, humidity favours the growth of entomophagous fungi which are a major factor in the natural control of scale insects which are of major importance in other citrus areas. Such areas are those of California, South Africa, and Australia, which have a dry climate and where citrus is grown under irrigation. Florida, Japan, and some parts of Queensland resemble the West Indies in humidity of climate and the consequent importance of natural scale control.

In Trinidad there is no very recognisable dormant season for growth. In more northerly and southerly latitudes a cool or frosty winter period occurs when growth of the trees is small, and this dormant period is represented in some warmer citrus areas by a dry season. The growth of citrus — the development of"flushes"of leaves and the production of fruit — is a year-round phenomenon in Trinidad. This, while in general an advantage, introduces some disadvantageous factors, as for instance the continuity of insect populations where these depend for a livelihood on the presence of young leaves, flowers or fruit. The point will be considered further in the account of the various pests.

Comparison of the yield per acre of citrus in Trinidad with that of California, a"dry"citrus area, is interesting(6).

Yield per acre in crates.

Trinidad, California(1941 - 45 average).

<table>
<thead>
<tr>
<th>Citrus</th>
<th>Trinidad</th>
<th>California</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valencia Oranges</td>
<td>140</td>
<td>338</td>
</tr>
<tr>
<td>Grapefruit</td>
<td>280</td>
<td>545</td>
</tr>
</tbody>
</table>
Though the larger yields of California cost more to produce in general management and care, fertilisers, and extensive and expensive control of pests and diseases, than those of Trinidad—
machinery, materials and labour for insect-control alone cost an estimated $4 million in California for 302,500 acres (10) — the economy of the methods used there cannot be in doubt.

Poor management and lack of care are primary factors reducing the yield of fruit in Trinidad, and it must be said that the figures given above do not by any means tell the whole story. A high percentage of the fruit produced here is so marked and blemished by scab, rust mite, thrips, scale and other pests and diseases, that it is quite unsaleable as whole fruit, and must be juiced at the Cooperatives Factory. This process is expensive and yields a cheaper product than whole fruit, and thus the grower loses a considerable amount of the value of his crop. The price difference between whole fruit and fruit for juicing is in general about $1 per crate, about 50% of the value of a crate of fruit to the grower in 1951. Moreover citrus juice is not nearly so saleable on the world market as West Indian citrus which is of a high quality. A general realisation among growers of the fact that greater care in citrus cultivation would reap ample dividends is one of the great desiderata for the Trinidad citrus industry today; and part of the new care required is in the better control of the pests of citrus.

It is probable that the major factors influencing the type and importance of pests in citrus growing areas are governed by the climatic variations between these areas and their relative accessibility.
Thus in two areas having similar climate and easy accessibility by sea, lines of rail or other means of transport, one can expect almost identical lists of citrus fauna, given time. Trinidad is important among the trade routes of the western world and it would be expected that its citrus pests bear a close resemblance to those of similar humid citrus areas in the west — in Florida, other West Indian islands and Brazil. This is found to be true to a great extent.

The existence of a similar citrus fauna in different areas does not however necessarily imply that the relative importance of the pests will be the same. In California different insects are major pests from those in Japan, though the citrus insects of these areas are similar, as they are on a direct trade route. In Trinidad itself, the order of importance of citrus pests differs from that of those in Florida, though the actual insects species present are very similar in both countries. Thus Watson and Berger[15] give the following six pests of primary importance in Florida:

1. Purple Scale.
2. Citrus Whitefly.
3. Rust Mite.
5. Florida Red Scale.

From which it is easily seen that citrus scales and whiteflies are of very great importance as pests. Of the next twelve pests in order, scales and mealybugs contribute five.

This extreme
This extreme importance of scale insects, Aleurodids and mealybugs as citrus pests is not so evident in Trinidad. These three groups of insects are to a great extent naturally controlled, particularly so the mealybugs and Aleurodids on citrus. Thus out of six pests important in Florida only one, the citrus rust mite is of major importance in Trinidad.

2. STATUS OF CITRUS PESTS IN TRINIDAD:

The terms "major" and "minor" are only relative as applied to pests. As has been seen the fact that a pest is of major importance in one area does not necessarily imply that it will be a major pest in another area. So far as Trinidad is concerned, the detailed study of its citrus pests has not advanced far enough for one to be able to say which pests are "major" and which "minor" pests. Before this could be done, a reasonably accurate assessment of the prevalence of each species over a number of years and over the whole citrus area, and its relative importance in reducing yield, would have to be made. In the present survey, reference to the importance of a pest is made entirely in the light of the observations of the writer and subject to the limitations described below. Assuredly there are pests which citrus growers in general regard as their major enemies, namely, Rust Mite, Black Bee, and Bouchac ant, but their testimony is almost bound to be based on casual observation, and much damage is ascribed to species which are commonly seen or known of but may have little to do with it. A good example of these points is the citrus Coccidae. These are generally understood to be minor pests in Trinidad, as will be seen later; but it cannot be claimed that this is so in the majority of the citrus areas of the world. An assessment of
the total damage and loss of yield resulting from
scale infestation in Trinidad citrus orchards would
I think prove their importance to be far beyond that
ascribed to them at present.

Several citrus pests important either
on a world scale or in areas very similar to Trinidad
are not represented here at all, notably the
Mediterranean Fruit Fly (Ceratitis capitata (Wied))
which is present in all major citrus areas except
California and Central America including Florida(10),
and Citrus root weevils (Diaprepes spp.) which are
very important in other West Indian Islands (3). The
chance introduction of any pest is to be guarded
against, and particularly so in the case of these.
So far as citrus is concerned in Trinidad, artificial
control is very secondary to natural control, and
where the latter is so important, a "new" insect freed
from the control of its natural enemies, once introduced
would be likely to become most injurious.

2. AIMS AND OBJECTS OF THIS SURVEY:—

By field survey work and
laboratory examination and other observations to
obtain some idea of the relative importance of the
pests of citrus both as a seedling and as an orchard
crop. Further, to observe the habits and life
histories of as many different pests as possible and
also the extent to which they are naturally controlled.
To summarise the control methods possible for use and
already used and make suggestions in regard to them.

4. LIMITATIONS:—

The period during which the survey
has been carried out has been approximately
9 months from October 1951 to June 1952. Variations
in insect
insect numbers and importance as pests during part of one wet season and one complete dry season have been observed. This has coincided with the main and the subsidiary cropping seasons and the period between them.

Time has not permitted as complete a study of the natural controlling influences over the populations of pests considered, either qualitatively or on the quantitative basis which is so important in assessing the value of parasites and entomogenous insects and fungi.

Since the biological control of citrus pests is in Trinidad by far the most important controlling factor, its more complete study would be of considerable value.

Field observations and collecting work have been done mainly at St. Augustine Nurseries, where both nursery and older plants are grown, and at the College New Farm where there are young trees just coming into bearing, and in the College orchard where the trees are quite old. Several visits to orchards in the Santa Cruz valley were made and orchards at Centeno, in the Central Range and at River Estate and in the Maracas Valley were also visited.
11. LIST OF PESTS FOUND ON CITRUS IN TRINIDAD.

The insects and mites found definitely to attack citrus will be dealt with in the following order, which corresponds in general to the order of their importance as pests in this survey:

4. *Atta cephalotes* L. and *H. octospinosus* Reich. - A parasol or cibachanta or black ant.
5. *Aphididae* and *Toxoptera aurantii* - Aphids.
6. *Cocceodes* spp. and *Othrella* - Leaf rollers. Fruit piercing and young fruit eaten and similar pests.
7. *Orthoptera*-various - Grasshoppers, crickets, katydids.
9. Lepidopterous larvae: -
   a. *Mactalonyx lanata* (Cram.)
   c. *Fantis thraco* Huemer - Leaf rolling skipper moth.
   d. *A Psyched moth."
   e. *Papilio sp.* (those?)
11. *Crematogaster* sp.
13. *Chrysolaelid* beetles: -
   b. *Homoptera acuminatilis* (F.) - Leaf roller.
1. **Order Acarina. Fam. Eriophyidae. Phyllocoptrum olivarius Ashm.**

**THE CITRUS RUST MITE:**

**DAMAGE:** This extremely small mite is much less obvious than the damage it causes to the fruits of all types of citrus. It is a sucking animal, piercing and feeding on the contents of the oil cells in the epidermis of the fruit, which subsequently dries up causing loss of the normal lustre, and the condition known as "russet" or "rust". The mites infest all green parts of the plant and their feeding on leaves and young branches causes a similar loss of lustre and interferes with normal growth. A severe attack may cause reduction in leaf-size, and it is probable that the attack on parts other than the fruit is more important than generally realised.

The marketing value of russeted fruit is much diminished — such fruit is used only for juicing in Trinidad. Infested fruit is also smaller, especially since the attack often takes place early in its development and retards this from an early stage. It is also claimed that the keeping qualities and sweetness are impaired.

**DESCRIPTION:** 0.12 - 0.15 m.m. long, yellowish vermiform mite with cephalothorax and tapering ringed abdomen. Mouthparts, paired maxillary palpi and paired mandibles, adapted for piercing plant cells. Two pairs of short walking legs and on the last abdominal segment a pair of caudal lobes used in locomotion.

**LIFE HISTORY:**
LIFE HISTORY: Up to 30 relatively large eggs are laid singly during the life of each female and they hatch in 4 or 5 days. No males are known and reproduction is parthenogenetic (18). Mites commence egg-laying about 10 days after hatching and so population build-up under favourable dry conditions is rapid. They are mobile; in my experiments they moved away from bright light across a standard microscope slide in about ¾ minute; but the most important means of distribution are probably on the feet of birds and more mobile insects, and by the wind.

A high percentage of the trees in Trinidad orchards are infested with the pest. A severe infestation on the fruit appears to the naked eye as a yellowish dust. Damage is often limited to a few fruit on a part of the tree, probably due to the limited locomotory powers of a new colony when introduced.

PHOTOTAXY: In the laboratory mites move away from strong light and shade to regions of medium illumination. This may account for localisation of "rust" on many fruits: very commonly when fruit are in contact on the tree russetting takes place on each fruit in a ring round the point of contact, where medium illumination occurs.

CONTROL: a. Natural:– The multiplication of mites is retarded by wet humid weather and a certain amount of control must occur here because of this. Predators include spiders, which are very common on citrus here, lacewing flies, predaceous syrphid larvae and ladybird beetles. During a dry spell however,
however, the number of mites increases sharply and in an average season a high percentage of fruit is spoiled. 50% of oranges and grapefruit produced in Florida are injured in some degree and though no estimation of the percentage damage in Trinidad is available, there seems little reason to suppose it lower than this.

b. Artificial:— Sulphur sprays or dusts, which have a fumigatory effect, are a very effective control but are little used in Trinidad. Spraying should be quite economic; a proprietary sulphur spray "Sulfinette" supplied by Messrs. Geddes Grant, P. O. S., costs about 10¢ per crate of picked fruit on a basis of two sprayings, the first at preblossom and the second at petal fall.

In 1951-52 the price difference between grapefruit suitable for export as packed fruit and fruit for juicing was 80¢ per crate and should in general be about $1. At the Cooperative Citrus Growers Packing Factory it is found that as a result of damage to the skin of fruit (including that due to mites, scab, and mishandling) 90% of the produce of some estates goes for juicing. In years when a large crop is produced in U. S. A. and elsewhere citrus juice is very hard to sell; thus this year a very large amount of juice remains unsold in the C. C. G. A. warehouses. Grade fruit from Trinidad is much easier to sell however, since it is of high quality. The grapefruit of the West Indies is placed beside that of Florida as the best obtainable.

**OTHER MITES.**

**RED MITE:** (Tetranycha ?) an 8-legged pinkish-red mite, 0.3 m.m. long was found commonly living in small colonies
small colonies covered by a light web on the underside of leaves. Damage to the leaf takes the form of yellowing and curling in the areas above the colony. These mites are found mainly on leaves of medium age.

**WHITE MITE:** (Tetramychus) an 8-legged white mite 0.3 m.m. long, found on the fruits and young twigs. It may be predaceous or a pest.


**SCALE INSECTS.**

A thesis submitted as part requirement for the A. I. C. T. A. on the subject of the "Citrus Coccidae of Trinidad" exists (8), but for the sake of completeness a short account of the importance and nature of these pests is included here.

Citrus Coccidae commonly found in Trinidad include:-

1. *Chrysomphalus ficus* (Ashm). Florida Red Scale
2. *Prontaspis citri* Comst. Orange Scale

Numbers 1-4 inclusive are the most troublesome pests.

5-6 inclusive are sometimes troublesome.

7-9 are rarely troublesome.

**DAMAGE:**
**DAMAGE:** *C. fiscum* is a serious pest particularly on young trees, causing yellowing of the leaves and loss of the normal photosynthetic function. *L. Gloveri* is often associated with die-back of twigs. These and *L. HACKII* often infest the skin of the fruit itself. *E. citri* appears to promote bark cracking, and "gumming" may follow. It is most common on the twigs and branches of older trees (15).

In general, as long as this level is not enough to render it economical to control the scales, particularly Soft Scale and Black Scale, are attended by ants, mainly *Crematogaster* sp. and *Azusa chartifex*, which build "carton nests" over them, protecting the scales and feeding on the honeydew they excrete. So excessive is the output of honeydew that much falls onto leaves and twigs and becomes the medium for the growth of "sooty mold" (6). The black layer thus formed over the leaves must prevent photosynthesis in them to a large extent by shutting off light and choking up the stomata.

The growth of scales and sooty mold on the actual fruits is a contributory cause of the need in the factory for complex brushing, cleaning, and polishing devices.

**CONTROL:** These pests are controlled naturally to a large extent.
large extent by entomophagous fungi and predatory insects, mainly Coccinellids. They are also parasitised by a number of Hymenoptera. In the humid climate of Trinidad the growth of entomophagous fungi is favoured and natural control is such that a fairly constant level of scale infestation occurs in all orchards where no artificial control measures are taken. There is a common belief that this level is low enough to render it uneconomic to control the scales but it is the opinion of this writer that this is erroneous.

Young citrus plants are severely affected by scale attack, to which one would imagine they are more liable being sparser in growth than older trees in humid orchards. At nurseries and some young plantations spraying with an oil emulsion or miscible oil, e.g. Albolineum, is done monthly. On older trees, where the damage is usually less extreme, spraying is seldom carried out except in certain orchards. The aim is generally to maintain a high humidity in the plantation so that natural control by entomophagous fungi will be at a maximum: "... the appearance of scale on citrus is nearly always an indication of insufficient wind-breaking — insufficient shelter from dessicating winds in the dry season which dry out and kill the fungi which check scale"—Lucie-Smith(6).

But though maintenance of a high humidity may be relatively easy in plantations in the sheltered valleys, the expanding industry is pushing new plantings into situations not so suitable, and particularly in years when a true "dry" season occurs, infestation by scales is liable to be more serious. Moreover, where control measures are taken
against rust mites and scab, as seems advisable, the fungicidal action of the sprays used will render it even more necessary to use artificial controls against scales, since entomophagous fungi will be killed. Watson and Berger in Florida, (15) where entomophagous fungi are similarly important controlling factors, state that fungicidal applications must be followed in two months by sprays to control scale insects.

Sprays include emulsified petroleum oils used with a spreader, a method which has reached a high standard of efficiency in U. S. A. (10). In Palestine calcium cyanide fumigation under tents has been successfully used (9), but the use of a spray method is perhaps more advisable as being simpler and involving less capital outlay. Latterly phosphorus compounds have been used: a product marketed here - Fosfeno Liquid 20 containing Parathion - makes up a spray costing \$2 a gallon.

**Mealybugs:** In this survey mealybugs were found to be rare on citrus.

**Order Hymenoptera. Fam. Apidae. Trigona trinidadensis.**

**The Black Bee:**

This is common in Trinidad and well-known among citrus growers, ranking as an important pest in the island. Besides citrus it attacks several other fruits including the banana. It is considered so important that a government order exists requiring any property owner to destroy nests found on his premises, but this does not appear to be rigidly enforced.
DESCRIPTION: Worker: 12-14 m.m. long from head to wing-tips, dark brown; head large, face bare, antennae geniculate, mandibles stout and 4-toothed. Thorax slightly larger than abdomen and with a pile of short hairs. Wings brown, translucent and held backwards at sides of body when at rest, the short rear wings outside the forewings which project the length of the body behind the abdomen. Abdomen smooth. Hind femora large, flattened and triangular with long stiff hairs along rear edge and shorter hairs along front edge. Sting vestigial as in Melipona: "stingless bees".

HABITS AND DAMAGE: The bees live in large nests in the hollows of trees and elsewhere, entrances to which are guarded during the day by workers which, though they do not sting, bite fiercely. The entrance to the nest usually projects as a conspicuous funnel closed at night with cerumen(5). The workers bite holes about 3 m.m. in diameter in the skins of fruit and extract juice from within. Apart from this primary damage which is quite sufficient to spoil the fruit for sale, fungal attack rapidly follows and fungal hyphae grow up the rags of the fruit causing it to fall when infection reaches the button end. This occurs in a few days in optimum conditions. The spores of the fungus concerned are airborne and also carried by insects and birds visiting the holed fruit to feed on the juice.

The bees also strip off bark from the younger branches but whether this is used as a source of resinous substance I did not discover. (Some stingless bees mix resins or mud with the wax secreted from between the abdominal sclerites to form cerumen). This damage to the bark must encourage infection by disease organisms (e.g. gummosis). Pickers will not
pick fruit from trees where the bees are nesting.

CONTROL: The nests are usually destroyed by burning, a mass of burning paper being used to ignite the nests which are quite inflammable. D. D. T. spraying or similar control would perhaps be preferable as producing less damage in the tree. Fruit should be picked as soon as it is mature (but see "Fruit-Piercing Moths.") Have personal safety damage.


PARASOL OR BACCHAC ANTS:

DAMAGE: These leaf-cutting ants are well-known from their habit of carrying crescent-shaped pieces of cut leaf projecting upwards above the body, which gives rise to one of the popular names of the species. These "parasols" are cut from the leaves of several kinds of plantation crops, particularly citrus, resulting in a very typical form of damage in which the edges of the leaves are deeply scalloped by the removal of curved pieces measuring from ½"-1" across the long axis.

The ants work mainly at night and in the early morning when numerous workers cut leaves with their powerful mandibles, to be transported by other workers to the subterranean nest. Here the leaf pieces are chewed up and prepared as compost used in the fungus gardens—open spongy masses on which the fungus Rozites gongyllophora grows: this fungus is the food of the ants.

New nests consist of a small chamber, made by the queen, and a small fungus garden (16). Older nests are often quite extensive, additional
chambers being usually constructed radiating out horizontally from the initial ones. Colonies of twenty feet in diameter are sometimes found.

Complete defoliation of seedlings by these pests, which is not uncommon, results in their death, whilst the attack on older trees is often severe and must reduce their yield. Trees in all the orchards visited have parasol ant damage.

**DESCRIPTION:**

:man:san(2.5-35) gives the following description: light about 1.5 m. high, yellow or green, hexagonal, entered with the third segment.

The nests are found in a row, shorter than separate ants. The column of ants defoliating the trees. This is usually a simple process, the columns sometimes being almost continuous. The nests are then destroyed by fumigation or an insecticide (Chlordane).

**CONTROL:** The most important species noted attacking citrus is *A. cephalotes*. This applies to cacao according to Urich(14). The entrances to the nests are traced by following back the column of ant defoliating the trees. This is usually a simple process, the columns sometimes being almost continuous. The nests are then destroyed by fumigation or an insecticide (Chlordane).

Various fumigation methods of control have had a vogue in Trinidad. Calcium and sodium cyanide dusts blown into the entrance holes have been used, but these substances are toxic to plants and Man and are particularly dangerous to young roots. Carbon bisulphide poured in entrance holes has been used considerably, but although it has a heavy vapour is not so penetrating as could be desired. The practice of subsequently igniting this vapour and waiting for the muffled reverberations to subside, which has been popular, was both dangerous and probably effected less efficient control than straight fumigation.
Chlordane, now available in quantity, affords an excellent control, being widely used to the exclusion of other methods.


**COTTON APHID:**

This aphid can be found commonly during spells of dry weather mainly on the undersides of the young flush leaves of citrus.

**DESCRIPTION:** Fennah (2. p. 56) gives the following description: "Adult about 1.5 mm. long, yellow or greenish-yellow. Antennae with the third segment with a few sense organs in a row, shorter than segments 4 and 5; segment 4 without sense organs; the basal part of segment 6 shorter than its terminal filament. The cornicles longer than segment 4 of antennae but shorter than 3 and the filament of 5. Caudal process elongate and constricted near middle. Forewing with distance between the second fork of Media and margin of wing more than one third as long as distance between first and second fork."

**DAMAGE:** Both adults and young suck sap from the leaves and this results in a curling and distortion of the leaf. This is presumably due to the collapse of empty cells on the underside of the leaves and consequent reduction in size. Subsequent growth of healthy cells on the upper surface intensifies the rolling and malformation. Generally rolled leaves on citrus are smaller than the normal ones when fully grown and quite apart from the primary loss to the tree by sap removal when the leaf is young, the transpiration relations and photosynthetic activity of these rolled leaves must be impaired.

If the aphids remain on the leaf they die when the leaf ages and the cuticle becomes thicker;
but as explained the curling of the leaves persists. A high percentage of leaves on the citrus in Trinidad are curled, though not necessarily because of aphid attack. These curled leaves are favourite sites for the webs of spiders of various kinds.

**CONTROL:** Good natural control of aphid populations is obtained during much of the year as a result of heavy rainshowers which are very destructive to aphids. It has been noted that of large thriving colonies only those individuals well protected in curled leaves survive the heavy shower. Direct washing off and splashes from other leaves account for the rest.

Predators include lady beetles, particularly *Cycloneda sanguinea*, which is common, and syrphid fly larvae, mainly *Baccha clavata*. Larvae of *C. sanguinea* will eat an average of 16 aphids a day, adults about 60 aphids a day (15), while the larvae of predatory syrphids feed voraciously on the aphid colonies, in which they are common. Considerable control is effected in California by Hymenopterous parasites(14), and this may apply in Trinidad: Walcott(17) cites *Aphidius spp.* as efficient Hymenopterous aphid parasites in the West Indies.

A good deal of artificial control using nicotine dusts and sprays on still days and also under tents is practised in Florida and California, and advantage is taken of the dormant winter season when aphid populations die out for lack of new leaf flushes to be colonised(15). But in Trinidad citrus produces flushes throughout the year and a level of infestation results, representing a balance between the growth of colonies and their death through the aging of flush and natural control, at the particular time.
There is evidence also that higher temperatures inhibit the development of aphids and the rate of producing young \((|)\). No control is practised in Trinidad.

**Toxoptera aurantii** is not so common on citrus as the above, but produces similar symptoms and is subject to the same controls.

5. **Order Lepidoptera, Fam. Noctuidae.**

- *Athyrsania(Gonodontia)choninea* Cram.
- *Athyrsania(Gonodontia)amianta* Hensen.
- *Athyrsania(Gonodontia)sinaldus* Guen.
- *Othrisia sp.*

**FRUIT-PIERCING MOTHS:**

A. *choninea* and A. *amianta* were taken piercing grapefruits and oranges at St. Augustine Nurseries during December and January when they were very plentiful during the period 8-10 p.m. A. *sinaldus* and *Othrisia sp.* are in the museum collection, the latter is said to be most plentiful during July-August.

**DESCRIPTION:** The *Athyrsania spp.* are medium sized Noctuids easily recognised whilst resting and feeding on the fruit since their wings are folded flat by the sides of the body the forewing projecting upwards and revealing its rear edge which has a curved indentation.

A. *choninea* about 3 cm. wing span. Chocolate brown or dark fawn, with a darker eye at the proximal edge of the scallop in the forewing. Ventrally lighter uniform shade of brown.

A. *amianta* 3 cm. wing span. Forewings are orange brown and hindwings brown with a prominent yellow eye.

A. *sinaldus* forewings a rich chocolate brown except at the tip which is light brown. Hind wings yellow proximally
and of a brown intermediate between those of the fore-
ing in the distal one-third.

*Othreis* sp. 7 cm. wing span, with light brown forewings
and the hind wings yellow proximally each with a
pronounced chocolate eye in the yellow, with a brown tip.

**DAMAGE:** These moths are the Trinidad representatives of
a group of fruit-piercing and sucking Heteroidea. Only
mature fruit is attacked, and puncturing is soon
followed by yellowing from the point of injury and
rotting round the puncture due to fungal action. Fungus
infection travels up the pithy material inside the rind
("rung") and so to the stem end of the fruit, and the
fruit falls. Attacked fruit before falling become musty
and distasteful. As many as 12 punctures have been seen
on one fruit (3) (4), and at St. Augustine fruits with
several punctures were common.

Fennah describes the operation of fruit
piercing as follows: "In puncturing the fruit the moth
uncoils the tongue and presses the barbed tip against
the surface of the fruit and rocks the tip on its point
by a rapid alternate inflation and deflation of the
tongue by blood pressure. The whole operation is completed
in a few minutes. . . . . A freshly made puncture caused
by *Gnonodonta*, measures 0.57 m.m. in diameter. . . . ." (3).

One surmises that as each juice-containing
vesicle of the fruit is pierced juice passes up the
probascis partly by pressure from within and partly by
suction by the moth. Juice exudes from the fruit for
some minutes after the removal of the moth.

**LIFE HISTORY:** details of the life histories of the
fruit-piercing moths are not well-known. (4). The larval
hosts of *Athisansa* are members of the Amonacese and
those of *Othreis*, vines of the *Menispermaceae*.

**CONTROL:** If fruit is picked as soon as it is mature effective control is achieved. However, this is difficult in Trinidad as ripe fruit has to be picked at intervals to suit shipping opportunities and particularly during the main season it is common for ripe fruit to remain unpicked for long periods.

Clean orchard practice and removal of larval food-plants round orchards may help to give natural control. Tryon(3) found that orchards adjoining *Menispermaceous* scrub suffer most from *Othreis* attack; but moths were also found sheltering in brushwood near orchards, where they could not have originated. These may have travelled long distances from their place of origin in search of fruit.

Poisoned baits, usually sugar solutions containing arsenical compounds were claimed successful in South Africa in 1929(1), but were used without success in Dominica(3). Repellant sprays gave protection for a few nights in Dominica: 2% Alboleum and 2% naphthalated kerosene sprays were used.

No control measures are at present attempted in Trinidad, though an important loss must occur.

6. **Order Orthoptera.**

**Grasshoppers:**

A good deal of gross leaf damage has been noticed in all orchards visited, and it is assumed that much of this is due to the attack of grasshoppers. The damage appears to be done mainly at night when feeding grasshoppers have been observed several times.

No species of grasshopper appears to be
particularly concerned with citrus. As they are general feeders, those common in the district will presumably be the ones doing damage. In Dominica Fennah (1942) found that a large amount of damage was done by Tettigonid grasshoppers and a series of nocturnal collections included: Anaulacemere laticauda Brumner; Neocnephtalus tripes L; N. maxilosus F; and species of Microcentrus, Conophora and Blisataes (3).

**CONTROL:** The damage done to young plants is the most serious and for them spraying with lead arsenate would be an effective control. In the case of older trees in orchards adjoining hillsides in secondary forest, invasions from outside the orchard constantly occur. Quayle (1928) suggests poison bran baits incorporating arsenical compounds spread round the orchard borders to prevent this (10). In the area under survey, orchards in the Santa Cruz valley suffered most from attack and the latter method of control should be applicable.

**Fam. Tettigonidae.** **Katydids.** **Cryptophyllus concavus.**

Eggs of the broad-winged Katydid, *C. concavus*, are often seen on citrus leaves. They are very characteristic, being flat oval yellowish-white discs placed in a single row along the edges of the leaves, usually on the lower surface, and overlapping each other in a very regular and symmetrical manner. The eggs are highly parasitised and whole rows occur in which each egg is punctured by the small round exit-hole of the parasite, probably a Hymenopteraan.

The adults do not seem to be common, at any rate during the day; they are however effectively camouflaged, being green and with wings closely resembling leaves.
**Fam. Gryllidae. Scapteriscus vicinus (Scud.) Mole Cricket.**

**DESCRIPTION:** described by Fennah as follows (2):

"Adult about 33 mm. long pale greyish brown, covered with a short velvety pile. Antennae tapering, many-jointed. Prothorax long and cylindrical, with sides convex. Anterior legs stout, the apical part of the tibiae with broad spinose projections which work scissor-wise across a similar group of teeth on the basal joint of the tarsi. Nymphs like the adult but smaller and devoid of wings."

**DAMAGE:** The nymphal stages and adults of this insect attack the stems of plants just below ground level and are sometimes of importance as pests of young citrus plants particularly in light soil. The bark and softer inner parts of the stem are eaten away and death of the plant ensues, preceded by wilting and yellowing of the leaves. Damage of this kind was found at St. Augustine Nurseries.

**CONTROL:** This is a pest of young plants in the case of citrus: the thicker bark of older trees withstands attack. Fennah suggests the use of poison baits or stirring calomel and talc on flour into the top inch of soil round the plants as a general control measure against mole cricket, and doubtless this treatment would be effective for citrus. The plants may be protected efficiently when transplanted, by a tough leaf or banana leaf sheath wrapped round the base of the stem and partly sunk into the soil (2). For transplantations in the wet season the second method appears to be most suitable since it is likely that insecticides would be washed out from the soil or rapidly lose effectiveness.


**DAMAGE:** Thrips are sucking insects attacking the floral parts, stamens and petal bases inducing early fall of these organs. If thrips are abundant, both the receptacle and
the tissue round the ovary itself may be attacked. Eggs may be laid on the young fruit and receptacle and further intense puncturing of these parts by the new generation can induce dropping of the young fruit size developing into cracks and rings of discolouration round the button end.

Small black thrips (unidentified so far but possibly Frankinielliella insularis) are very common at the base of citrus blossoms particularly in the dry season. Their presence in large numbers is associated with a certain amount of petal fall and dropping of small fruit. It was difficult to estimate to what extent these observations were related.

Serious damage of the type described for Scirtolbrinae citri (10) was not commonly seen. It is felt that general surface discolourations and tear marks which may occur from thrips damage may have been masked in many cases by russetting from Rust Mite attack.

Leaf-eating Lepidopterous larvae.
Megalopygidae. Megalopyge lunata (Cram).

This species is recorded on citrus in Brazil (10) and is of the same genus as M. canencularis, the Puss Moth, which is a minor pest of citrus in Florida and the Gulf States. It was common on citrus at the College New Farm during January to April but has not been taken elsewhere in this survey.

DESCRIPTION: Eggs light yellow 3 m.m. x 1.5 m.m. Fully grown larvae 7 cm. x 1 cm. extended, contracts to 3 cm. x 1 cm. White to fawn covered with long brown hairs arising from brown papillae. Well-formed mandibles at base of conical depression; 3 pairs short conical thoracic legs; pairs of crochet-bearing U-sectioned abdominal prolegs on segments 3 to 6, and on 10. Pairs of suckers without crochets on 2-7 inclusive. Red-brown papillae
in 3 paired rows, laterally and dorsolaterally 2 pairs
on thorax and 6 pairs on abdomen; between these rows are
the 9 pairs of spiracles. 11 pairs of papillae dorsally.
All papillae bear long brown hairs and short stiff
sharp red-brown stinging hairs.

ADULT: Wing span 6 cm. Body length 3 cm. Wings fawn
with brown veins and brown markings anterior half of
forewings dorsally hirsute. Antennae finely bipectinate.
Thorax thickly hirsute chocolate brown with pink markings.
Forelegs with long brown hairs along posterior edge;
meso- and meta-thoracic legs similar but with pink hairs
on femora. Abdomen hairy with 6 pink annular markings
alternating with 6 brown. Posterior one-third with
dense fawn hairs.

♂: Wing span 4 cm. Similar to ♀ but
slight differences in markings on wings and thorax.
Abdomen with 7 alternating stripes of pink and brown.
Fawn tip smaller than in female.

DAMAGE: The larvae are gross feeders on leaves
resulting in severe defoliation particularly when
several feed together.

LIFE HISTORY: During January and February the following
life history was worked out from observations in the
field and laboratory.

About 400 eggs are laid in batches of about
15 on the upper surface of leaves and covered with white
to fawn "wool" i.e. hairs from the female abdomen. The
larvae when hatched feed on the upper surface of the
leaf, leaving the lower epidermis which later shrivels
up. When the larvae are about ½" long they begin to
feed on the whole leaf and when present in numbers
defoliate whole branches.
Before pupation the larvae migrate down the stem and settle gregariously on the main axis or a wide branch, subsequently turning round and facing upwards. The tactic responses involved in this movement presumably dictated by *geotropism* must be complex. Each larva now spins a cocoon of silken threads, entangling its longer hairs and these fall off forming part of the meshwork. The cocoons are adherent to the tree and close to each other. Up to 12 have been seen on one tree.

Inside the cocoon the larva produces a tough membranous case of characteristic shape and after a variable prepupal stage, pupates, casting its skin which shrivels and remains covering the tip of the abdomen. The pupa is quite free in the case and rotates if disturbed. The pupal covering is brown, thin and membranous becoming darker with age. A feature unusual in *Lamidontara* is that the appendages are entirely free from each other and the body wall.

Pupation lasts 4 weeks, when the whole pupa breaks through the anterior end of its case, which has a line of weakness, and the pupal skin is split along the dorsal midline as far as the abdomen, the imago emerging and hanging for a short time by its strongly hooked claws to the silken cocoon before it inflates its wings and flies off. The pupal skin is left projecting from the cocoon: the absence of a lid-like operculum to the pupal case appears to be unusual among *Megalopygidae*.

**CONTROL:** If found to be a source of trouble this moth like the rest to be described (except *Eanhis hexaso*) could be controlled by hand-picking off the larvae.

A high percentage of intact cocoons picked off citrus in March were found to contain no pupae, and each had a small round hole 1 m.m. in diameter
in the pupal case. It is apparent that some natural control by parasites occurs and this seems quite efficient; out of the nine pupae on one tree, eight had been parasitised.

8. **Order Lepidoptera**. **Fam. Limacodidae**. **Phobactron**

**Liparcida.**

**THE HAG MOTH:**

This species is a gross feeder in the larval stage which, like *Megalonyge lanata*, I have found only on Grapefruit at the New Farm. It was present from December onwards, sometimes occurring in numbers – several per tree – but in general it does not seem to be sufficiently common to cause great damage.

**DAMAGE:** Defoliation of branches, but not so severe as in the case of *M. lanata*.

**DESCRIPTION:** Only the larvae and cocoons were seen; attempts to breed out *imagines* from these failed. From dissection of a dead pupa the *imagе* appears to be a small to medium-sized moth with light brown wings having dark-brown spots and markings.

**LARVA:** 4 cm. x 1 cm., brown. Head retracting into a fleshy pit provided with short stiff bristles and a few long sensory hairs. Thoracic legs minute, abdominal feet absent. Conspicuous armature of 9 paired curved hairy protuberances arising dorsally along body behind head; 4th. and 6th. quite short with long stiff bristles and pigmented distal eyespots, these may be light-sensitive: 2, 3, 5, 1 cm. long; 1, 7, 8, 9, shorter, all densely covered with short soft hairs and fawn proximally, dark brown distally. Below curved projections a continuous row of 12 small hemispherical protuberances clothed with short stiff stinging bristles.
A few experiments were done to ascertain if the projections have any physiological significance. They contain evaginations of the haemocoel. Several can be removed without apparent harm and little loss of haemocoelic fluid, since communication with the main body cavity is through a very narrow canal through the tissue blocks forming the base of each projection and this closes very quickly. However upon removal of all the projections from one caterpillar it died. There was no evidence that the projections are essential in the performance of some physiological function; they appear to be elaborate protective devices perhaps as camouflage for their presence makes the larvae resemble Tarantula spiders or twisted dried up leaves. The projections are also used to cover up the cocoons, camouflaging these very well.

The cocoons, attached in the forks of twigs, are ovoid, about 2 cm. x 1 ½ cm. The pupal case is brown and tough, plastered with hairs and projections from the larva. They open by a small round operculum splitting off along an annular line of weakness. The pupae like those of *M. lanata* are free within and have their appendages free from the body wall. There is a prepupal stage.

Watson and Berger claim that *Phobertron* sometimes causes damage in Florida by several larvae together gnawing off a twig. I have not observed this here.

**PARASITES:** An unidentified Hymenopterae parasites young larvae and appears to develop completely within them. The larvae become mere skins containing a thin white membraneous case in which is the adult parasite. All specimens of the parasite were found dead and the method
of escaping from the dead host was not elucidated.

The importance of this parasite as a natural control was not estimated, as appearances of the young larvae was too spasmodic. No parasite was found in older larvae.


_Citrus Leaf-roller:*

A number of leaves with folded indentations were seen on citrus at the New Farm and St. Augustine. Inside the folds, which are stuck down by silk which they produce, were larvae of a leaf-rolling Hesperiid, which from the description given by Walcott (17) appeared to be *Banthia thraco*. No adults were obtained from pupae.

**DAMAGE:** Tender leaves are folded longitudinally along part of their length, the larvae remaining inside the fold scraping the leaves in the early stages and later on eating them from tip to petiole, leaving smooth edges to the damaged parts.

**DESCRIPTION:** Larva: when young pale yellow with brown or black heart-shaped head; fully grown, green and 2-2½ cm. long. Body tapers at ends. Pupation in silken cocoon inside leaf fold.

The larvae are essentially flush-feeders, and as such were more common in the rainy season, when more flush occurs. They did not appear to do significant damage: one larva eats only one or two good sized leaves during its life. Only one larva occurs on a leaf.

**CONTROL:** If sufficiently abundant to warrant it, this is the only caterpillar referred to which cannot successfully be controlled in my opinion by hand-picking. As single spraying with lead arsenate should suffice.
The larva of *Toonica zizyphi*, another citrus leaf-roller, has been important in Southern India as a pest of seedlings, but though leaf-roller damage was common on young plants at St. Augustine, it did not appear to be very important. The larva of *T. zizyphi* appears to resemble the one described here closely.


**Bagworms**

Occasionally Psychid moth larvae in their curious cases were seen attached to citrus leaves in the various places visited. The cases are bags of matted silk covered with short sticks cut by the larvae and stuck tangentially to the silk bag so that the ends protrude. The larvae never leave their cases and carry them about, feeding on leaves. They are not sufficiently common here to do important damage.

In Florida the Orange Bagworm (*Platopsoceticus gloverii* Pack.) has done considerable damage at times, eating into fruit rind and feeding on the leaves and epidermis of tender twigs.

The Bagworm found here produces a bag up to 5 cm. long. The larvae are highly and have strong mandibles, and are orange yellow into dark brown markings. Adults were not found.


**Orange Dog:**

A single adult was taken in the College citrus orchard. The larvae of various species of *Papilio* are gross feeders on the leaves of citrus and are referred to as "orange dogs" because of their appearance. *Papilio cresphontes* is listed as a major pest of citrus by Quayle, who states that two or three individuals can completely defoliate a young tree in a few days.
As larvae were not seen at all it is assumed that they are uncommon here. *Papilio app.* larvae are in general brownish and large when full grown - 6 cm. long - and thick. The most characteristic features are a pair of bright coloured fleshy bones which are distended when the larva is alarmed, and emit a strong odour, supposed to protect it from enemies.

The adult is a large black butterfly with bright yellow bands and markings and swallowtails each with a yellow eye.


Though no specimens of this species were taken in the survey, it is known to appear spasmodically in Trinidad. The larvae are gregarious feeders and produce defoliation damage on citrus. Their gregarious movements are said to be curiously regular, all larvae in a group moving together to and from new feeding places at regular times.


*Solenopsis gaminata E.*

*Crematogaster.*

*Astea chartifex* Forel.

The activities of these ants in protecting scale insects from enemies and under carton covers made of earth and chewed up wood have already been noted. All are quite common wherever scales are found, *Crematogaster* being particularly so. The latter is very small (1½ m.m.) and black, carrying its abdomen elevated at right angles to the body when excited and often having a small white spherical blob of excrement at the tip of the abdomen. All these ants are pugnacious in their defence of nests
and scales, particularly *Solenopsis geminata*.

*Solenopsis geminata*, in addition to protecting scales is said to become a direct pest at times. "When their supply of food is suddenly cut off, ants often attack the young tender shoots........ eating them at the point where they join the branches. They also eat young tender leaves, and a few cases have been observed where they had cut holes in ripe fruit". *(V).* I have not observed any damage of this sort however.

**CONTROL:** Ants can be controlled efficiently by the use of chlordane. Merely knocking down and breaking up the nests, which is often done, is quite ineffective.


**Flea Beetle:** Adult flea beetles were found fairly commonly on lemons at the New Farm during dry spells of weather.

**DAMAGE:** The leaves are "shot-holed" and in a large infestation become ragged.

**DESCRIPTION:** Adult: very small, black shiny head at right angles to body with prominent 4-toothed mandibles. Gregarious, appearing in very large numbers on single plants and usually localised on the plant itself. Legs long and hind femora greatly swollen, giving rise to power of sudden leaping when disturbed, a habit which is very characteristic.

15. **Order Coleoptera. Fam. Chrysomelidae. Homophoata sequinostalia.**

**DAMAGE:** Found eating tender leaves and petals, cutting out very curved small pieces.

**DESCRIPTION:** Adult 6 m.m. long. Elytra shining black with 4 characteristic yellow markings on each. Prothorax pink to orange. Legs black.
Not common enough to do significant damage, but along with thrips may assist in causing early petal fall and poor fruit setting.

**Diabotica capitata**: feeding habits and damage similar to *H. equinoctialis*.

**DESCRIPTION**: 6 m.m. long. Elytra yellow with characteristic brown markings. Thorax yellow. Legs yellow. Abdomen brown.

Both the last two species attack vegetables and sugar cane also (2) and were found at the New Farm. It is possible that they were chance feeders on citrus, but this seems unlikely since they lived for some time when fed on citrus leaves and flowers in the laboratory, and it would seem that citrus feeding in general must be specialised since the oil and aromatic content of the leaves is unlike that of other plants. *D. soror* lec and *D. balteata* lec. are major pests in California (10).

Neither species was common enough to do great damage.

Syrphid larvae are often present among aphid colonisation leaves. Few species appear to be concerned and all larvae tend to have been of *Pemphigus vivax*. The larvae have sharp mouthparts with which they pierce the aphids and suck out the body juices, leaving the dried-up skins on the leaves.

**Mycopha** are very common on the citrus here, and must be an important controlling influence. Occasional *Gasteria* are also seen.

Spiders of various kinds, usually constructing a web in a folded leaf of leaves and living in wait for prey, are exceedingly common on citrus here. Several
A number of predaceous insects and spiders afford a certain amount of natural control on the numbers of citrus pests, particularly of the soft-bodied insects. Melville lists 12 coccinellids feeding on coccids on citrus and in the course of the present work Cyclonada sanguinea, Pentilia sp., Hyasaenia balloti and Macálvia 18-guttata were seen attacking aphid colonies, the latter at night. Ladybird beetle larvæ are also efficient predators on soft-bodied insects.

The green lacewing fly is a common insect in orchards, and the larvæ of this species appear to be fierce predators. The eggs are laid elevated on small thin filaments on leaves so that newly hatched larvæ cannot attack them, and the larvæ use their powerful curved piercing and sucking mouthparts (grooved mandibles overlying maxillae) to feed on scale insects by passing their mouthparts under the scale on opposite sides and piercing the soft-bodied insect below.

Syrphid larvæ are often present among aphid colonies on leaves. Few species appear to be concerned and all larvæ bred have been of Baccha clavata. The larvæ have sharp mouthparts with which they pierce the aphids and suck out the body juices, leaving the dried-up skins on the leaves.

Reduviids are very common on the citrus here, and must be an important controlling influence. Occasional Mantids are also seen.

Spiders of various kinds, usually constructing a web in a folded leaf or leaves and lying in wait for prey, are exceedingly common on citrus here. Several
times I have observed spiders killing and sucking body-juices from flies, small moths and, once, a lacewing fly. Their value in keeping down numbers of citrus pests is hard to estimate.

A comparison is also made between the various citrus pests and their status here and in citrus areas elsewhere having similar conditions. The status of the different citrus pests in Trinidad is discussed. The great reliance placed on natural control of pests here is described and mention is made of the importance of guarding against the introduction of foreign pests which might not be controlled naturally and could radically interfere with the "balance of Nature" already weighed in favour of the pests.

Over thirty different species of insect and mites which have been found to be in varying degrees pests of citrus in Trinidad are described and the importance of the damage they do roughly assessed. Brief accounts of the natural control and of artificial control methods practised are given for each type of pest mentioned and suggestions for further methods of control are made.

A general account of the predators found to attack various citrus pests is given.
The growing importance of the citrus industry in Trinidad and the reasons for this are summarised. The standards of the methods employed in citrus cultivation and the yields obtained here and elsewhere are compared. A comparison is also made between the various citrus pests and their status here and in citrus areas elsewhere having similar conditions. The status of the different citrus pests in Trinidad is discussed. The great reliance placed on natural control of pests here is described and mention is made of the importance of guarding against the introduction of foreign pests which might not be controlled naturally and would radically interfere with the "balance of Nature" already weighted in favour of the pests.

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The writer would like to express his gratitude to Professor T. W. Kirkpatrick and Mr. R. G. Fennah of the Imperial College of Tropical Agriculture, for helpful advice freely given at all times. Thanks are due also to the owners and overseers of citrus orchards who have been of assistance, and to the management of the Cooperative Citrus Growers Packing Factory.
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