INTEGRATED PEST MANAGEMENT ESPECIALLY BY
NATURAL CONTROL IN CITRUS CROPS

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Up to 1960, the farmers of Guangdong Wangtong, used the red citrus ant (Oecophylic smaragdina Fabr.) to control the citrus insect pests, and only sprayed one or two times of insecticides to control the bud feeder (Citea metallic Chen). The author had investigated the orchard, the ant used mainly to control the stink bug (Rhynchosorilis humeralis Thunberg) and no other serious insect pests were seen in that orchard.

From 1960 on, more and more chemical insecticides were used to control the citrus insects. On the opposite, the target insect pests rose both in number and species. Now we have to control the citrus red mites, rust mite, citrus leaf miner, citrus psyllid, aphids, citrus stink bug every year. Moreover, in many orchards, scale insects, whiteflies, and leaf rollers are also key pests causing serious damage.

With an aim to protect the natural enemies and to minimize the application of insecticides in citrus orchards, the author designed a small citrus orchard in 1979 to control insect pests mainly by their natural enemies and cultivation methods.

Before planting, the seedlings were heated at 49°C for fifty minutes and sprayed with streptomycin to eliminate yellow shoot disease and canker, at the same time so were the insect pests present.

Because the experimental orchard was not isolated, the common insect pests of citrus had continuously accessed to the orchard. All 22 species (Table 1) which have been recorded as serious pests in Gu-
For the last 30 years the orchard was managed by third-generation farmers who had inherited the land from their parents. After the application of IPM no one but the rust mite is needed to be controlled in the whole orchard.

Table 1  Insect pests collected in the experimental orchard

1. Rhynchocoris humeralis Thunberg.
2. Diaphorina citri Kuw.
3. Dialeurodes citri R. & H.
4. Aleurocanthus spiniferus (Quaint).
5. Aphis citricidus Kirkaldy.
6. Toxoptera aurantii (F.)
7. Icerya purchasi Mask.
8. Nipaecoccus vastator (M.)
10. Aonidiella aurantii (Mask.)
11. Lepidosaphes beckii (Newm.)
12. Lepidosaphes gloverii (Pack.)
13. Parlatoria zizyphus (Lucas.)
15. Anoplophora chinensis Forst.
17. Phylocnistis citrella Stainton
18. Homona coffearia Nieth.
19. Adoxophyes fasciata Wals.
20. Papilio polytes L.
22. Panonychus citri McG.

Between 1981 and 1982, the citrus white flies occurred on about half of the trees and sooty mold disease followed also. The whiteflies moved in from the neighbouring plots of seedlings where organic insecticides were sprayed frequently. In January of 1982, tap water was sprayed to wash the leaves, and 4 months later the whiteflies were controlled by natural enemies and no other control measures were needed. Following experiment was conducted to explain the action.
## Table 2. Rate of parasitism of whitefly pupae in different orchards with different control measures

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Location</th>
<th>Date of sampling</th>
<th>Leaves with pupae</th>
<th>Average leaves with pupae of whiteflies collected in one minute/person</th>
<th>Total pupae</th>
<th>Average pupae per leaf sm of pupae</th>
<th>% parasitism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orchard No.1</td>
<td>Experimental orchard</td>
<td>April, 1983</td>
<td>71</td>
<td>1.3</td>
<td>223</td>
<td>3.1</td>
<td>56.6</td>
</tr>
<tr>
<td></td>
<td>Experimental orchard</td>
<td>May, 1984</td>
<td>125</td>
<td>4.17</td>
<td>202</td>
<td>1.52</td>
<td>60.89</td>
</tr>
<tr>
<td>Orchard No.2</td>
<td>Dongguan westlake</td>
<td>May, 1984</td>
<td>135</td>
<td>4.21</td>
<td>131</td>
<td>0.97</td>
<td>51.16</td>
</tr>
<tr>
<td>Orchard No.3</td>
<td>Dept. of Pomology</td>
<td>May, 1983</td>
<td>460</td>
<td>1.6</td>
<td>273</td>
<td>2.8</td>
<td>33.3</td>
</tr>
<tr>
<td>Orchard No.4</td>
<td>Dept. of Pomology</td>
<td>May, 1984</td>
<td>121</td>
<td>5.26</td>
<td>377</td>
<td>2.86</td>
<td>4.51</td>
</tr>
<tr>
<td>Orchard No.4</td>
<td>Dongguan</td>
<td>May, 1983</td>
<td>460</td>
<td>6.9</td>
<td>1854</td>
<td>4.0</td>
<td>4.9</td>
</tr>
<tr>
<td></td>
<td>Dongguan</td>
<td>May, 1984</td>
<td>121</td>
<td>3.97</td>
<td>382</td>
<td>3.18</td>
<td>2.09</td>
</tr>
</tbody>
</table>

*No organic insecticides used  
** 3-4 times of insecticides sprayed per year  
***Less than 12 times of insecticides were used per year  
**** 3-4 times of insecticides sprayed per month
of the natural enemies. From 1983-1984, experiments showed that the parasites (mainly Prospaltella lahorensis H.) were the main factor controlling the whitefly and over 58% parasitism was seen in our experimental plot. As to an orchard in which insecticides were used indiscriminately, lower than 5% parasitism was found (Table 2). In the latter orchard, the number of whitefly eggs per leaf was high (Table 3), but the densities of nymphs and pupae were even lower than our orchard. However, if the spraying stopped, the density of the whitefly might rise immediately. By the results of two years' experiment, we believe that under normal conditions, the whitefly is not a serious pest in Guangdong. But with misuse of the organic insecticides, the pest might become a serious problem.

The citrus red mite (Panonychus citri McGregor) is the most difficult problem in our province and we suppose that this is owing to the misuse of insecticides also. In the first two years of our orchard, since ecological balance was not yet established, about half of the trees were injured by the mites. The acaricide, Amitra-and plictra were used to control the mites but their effects lasted only for several weeks and the mite population rose after one or two months. In 1983, we released the predaceous mite, Amblyseius nucleoli and A. deleoni.

Table 3. Density of eggs of citrus whitefly under different control methods

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Location</th>
<th>Leaves calculated</th>
<th>Leaves with eggs %</th>
<th>Total eggs</th>
<th>No. of eggs per leaf</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural control</td>
<td>experimental</td>
<td>105</td>
<td>89</td>
<td>664</td>
<td>6.3</td>
</tr>
<tr>
<td>Use insecticide in-</td>
<td>orchard</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>discriminate</td>
<td>Dongguan</td>
<td>239</td>
<td>219</td>
<td>3848</td>
<td>16.1</td>
</tr>
</tbody>
</table>

*225*
Table 4. No. of predacious natural enemies in sprayed area and controlled area
(One person collected half an hour in every area)

<table>
<thead>
<tr>
<th>Date</th>
<th>Controlled area</th>
<th>Sprayed area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sept. 29</td>
<td>Stethorus spp. 4</td>
<td>Stethorus spp. 5</td>
</tr>
<tr>
<td>(one day before spray)</td>
<td>Agistemus sp. 1</td>
<td>Agistemus sp. 2</td>
</tr>
<tr>
<td></td>
<td>Spiders 4</td>
<td>Spiders 8</td>
</tr>
<tr>
<td>Oct. 21</td>
<td>Stethorus spp. 2</td>
<td>Agistemus sp. 1</td>
</tr>
<tr>
<td>(two days before the 2nd spray)</td>
<td>Agistemus sp. 2</td>
<td>Spider 1</td>
</tr>
<tr>
<td></td>
<td>Spiders 11</td>
<td>Spider 1</td>
</tr>
<tr>
<td>Nov. 6</td>
<td>Stethorus spp. 3</td>
<td>Stethorus sp. 1</td>
</tr>
<tr>
<td></td>
<td>Agistemus sp. 3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spiders 9</td>
<td>Spiders 5</td>
</tr>
<tr>
<td>Nov. 26</td>
<td>Stethorus spp. 5</td>
<td>Stethorus sp. 1</td>
</tr>
<tr>
<td></td>
<td>Agistemus sp. 10</td>
<td>Spiders 5</td>
</tr>
<tr>
<td></td>
<td>Spiders 6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Amblyseius Spp. 7</td>
<td></td>
</tr>
</tbody>
</table>

which inhabited Bauhinia blakeana Dunn and Agrutum conyzoides Linn, and the density of the red mites lowered and has remained under the level of two mites per leaf up to now. Thus, the red mite has become an unimportant pest. In the orchard were found many natural enemies such as Chrysopa spp., Stethorus spp., Anystis sp., Agistemus sp., Amblyseius deleoni M.et D., Amblyseius nesolsi and the entomophagous fungus Cladosporium cladosporioides etc. Under the control of these enemies, the population of the red mite could hardly rise above the control level under normal conditions.

Among the natural enemies, Amblyseius spp., are efficient enemies of the red mite. Our research showed that when the density of Amblyseius spp., reaches over 0.2 per leaf the density of red mites would quickly going down, and no other control measures were needed. But the balance will be destroyed any time when organophosphorus and synthetic pyrethroids were used. The use of the Japanese insecticide Sumicidin (20% Emul.) is a typical example. Notwithstanding the
Sumicidin is specific for the citrus leaf miner and used commonly in citrus orchards in Guangdong. However, citrus farmers said that the red mites have been increasing year by year in recent 3-4 years.

An experiment was done to determine the effect of Sumicidin on the population of the red mite. Twenty trees were sprayed (1:3000 at the first spraying, 1:5000 at the 2nd spraying) two times in September and October 1983. The density rose dramatically in less than a month. The experiment was repeated in 1984, a lower dosage of Sumicidin (1:10000) was used and the red mites increased as in 1983 (Fig. 1(b)). Although only 1/5 of the trees were sprayed, the predacious enemies decreased markedly, and no Amblyseius was found (Table 4).

Citrus leaf miner (Phyllonícis citrella Stainton) is also one of the serious pests in citrus orchards. The miner is the most important pest during the shooting period of autumn. If the shooting period was timed for the late in July to the beginning of August, most of the shoots would escape the damage of the miner. But when the shooting period was delayed to after the middle of August, the proportion of injured leaves would rise sharply (Fig. 2).

In Guangdong shooting at the last of July and beginning of August is practical, and now the farmers are doing this in most of the citrus orchards.

Citrus psyllid (Diaphorina citri kuwayama) is the vector of the yellow shoot disease of citrus trees. Under natural circumstances this insect is not a serious pest. Our experiment of 1979-1981 showed that the number of generation of psyllids is directly related to the shoots of the citrus. Only in the closed young leaf can the eggs hatch, and the survival rate is very low, in our orchard, only 0.43%-0.8% survived (From egg to emergence). However, in an orchard where chemical insecticides were used 12-18 times a year, the survival rate of psyllids was 2.2-17.5% (The data from a 18-generation observation). The leaves of diseased trees fall continually all of the seasons. So the number of generations of the psyllids increases accordingly. In normal orchards, shooting takes place three times a year, so the psyllids cannot grow as many generations as in diseased trees. There are some psyllids in our orchard, but no yellow shoot disease was found, so the
psyllid is not a problem.

Aphids appeared in all the three shooting periods, when the shooting in the whole orchard is uniform, less than 3% shoots were injured, and no control measures were needed.

Rust mite (*Phyllocoprira oleivora* (Ashmead)) is the key pest in our orchard. Outbreaks of the mites occurred in spring and autumn 1983, also in autumn 1984. The entomophagous fungus *Hirsutella thompsonii* F. was used, but efficacy was seen only when the humidity in the orchard was very high. Aphicidin (An antibiotic insecticide produced by Zhejiang Province) was used and found to be an efficient miticide.

The above four-year study demonstrated that the control of citrus insect pests mainly by natural enemies was practicable. We consider this approach beneficial from the economical, ecological and sociological and is worth to be extent to the citrus orchards.

Fig. 1. Density of *Panonychus citri* McG. in the experimental orchard 1982～1985 (SCAU, Guangzhou)
Fig. 2. Density of the larvae of *Phyllocnistis citrella* related to the shooting period

REFERENCES


4. Division of Biological control, Kwangtung Entomological Institute, et al 1978 Studies on the integrated control of the citrus red mite with the predaceous mite as a principal controlling agent—*Acta Entomologica Sinica* 21(3): 260-270

以自然控制为主的柑桔园害虫综合治理

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摘要

为了达到最低限度使用或不用农药防治害虫，保护柑桔园的害虫天敌并发挥它们防治害虫的作用，作者于1979年开始种植了一个柑桔园进行观察试验。果苗全部经过清除黄龙病及溃疡病处理，果园面积一亩一分地，种以甜橙为主的柑桔110株。

经过五年多的观察，虽有黄龙病及溃疡病未见发生外，五年中除第一、二年使用过杀螨剂及柴油乳剂部分柑桔树中治红蜘蛛外，全园未使用过生理杀虫剂。

五年中广东常见的22种害虫已陆续进入试验园，除红蜘蛛在1983、1984年全园发生过外，未见有其他害虫在全园发生到需要使用药剂防治的水平。

1981—1982年柑桔粉虱曾于周围植株上发生蔓延到部分树上，但4个月内由于天敌控制迅速下降。该虫主要受蚜小蜂Prosapia laticollis H. 控制。在试验园中寄生率高达50%以上，而施用农药的柑桔园寄生率在5%以下，调查结果证明在广州正常情况下粉虱不是一种需要防治的害虫，但在使用农药不当时，随时可以引起大发生。

柑桔红蜘蛛（全爪螨）在试验园中仅在第一、二年在部分树上发生，释放钝绥螨Amblyseius daleoni及A. necosi控制取得成功。5年中全园红蜘蛛密度没有超过平均每头2头的防治指标。试验证明钝绥螨是控制红蜘蛛的有效天敌，在平均每叶超过0.2头钝绥螨的柑桔园，可以完全受控制。

速灭杀丁是破坏红蜘蛛生态平衡的典型药剂，在3000，5000，10000倍液喷射1—2次后20天内红蜘蛛直线上升（见图一曲线b），5年的观察证明红蜘蛛在正常情况下，不受农药的影响时在柑桔园中可以长期处于防治指标以下（见图一，曲线a）。

利用七月底八月初潜叶蛾低峰期放秋梢是控制柑桔潜叶蛾为害的有效措施。在试验园中五年来都利用这一措施放梢，没有使用过农药。

如果没有病原的柑桔园中柑桔木虱并不是一种需要防治的害虫，在试验园中木虱（自卵—羽化）存活率仅0.43%—0.8%，而每年使用12—18次杀虫剂的柑桔园存活率达2.2—17.5%，黄龙病树由于不定期放梢可以大大增加木虱的发生量。

锈蜘蛛是试验园中存在的最严重害虫，杀螨素可以有效地抑制该螨。

从试验园的结果证明，以自然控制为主的柑桔害虫综合治理，可以收到经济、生态、社会效益，是值得推广的柑桔害虫防治措施。

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