Biological Control of Psyllid Vectors of Greening Disease on Reunion Island

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Greening was first reported on Reunion in 1967 by Moreira (1967) and comfirmed by Bové and Cassin (1968) following their discovery of greening on the highlands of Madagascar (Lafleche and Bové, 1970).

Reunion shares with Mauritius and Saint-Helene Islands the privilege of harboring both vectors of greening: *Trioza erytreae* (Del Guercio), the African psylla which is the only psyllid vector present in South Africa and Madagascar and *Diaphorina citri* Kuway., the Asian citrus psylla. As shown in figure 1, the Reunion *T. erytreae* is prevalent above 400-500 m, while *D. citri* is more abundant in the lowlands on the leeward side (Bové and Cassin, 1968; Catling, 1972; Aubert, 1977).

In the 1960's, greening was so severe that it was generally thought that citrus could not be grown on the island. However, the following three factors have given citriculture a new start: introduction of disease-free budwood from Corsica; antibiotic treatment of affected trees; and biological control of vectors. This paper deals with the biological control of the psyllid vectors of greening in Reunion. Parasites were first sought on the island. Five occasional predators in the families Coccinellidae, Sirphidae, and Miridae have been identified (Etienne, 1978). They were unable to reduce levels of psyllas due to a conspicuous time lag in predator buildup during the spring flush of growth when the psyllas rise to high populations. An endoparasite of *D. citri, Psyllaephagus harrisoni* Robinson, was found but turned out to be only slightly effective. Hence, it became necessary to introduce efficient parasites from abroad and increase them by rearing on the two psyllid hosts before releasing them in the field.

BIOLOGICAL CONTROL OF *T. ERYTREAE*

Rearing of the African psylla in a controlled environment. *T. erytreae* was raised on *Citrus taiwanica* and Eureka lemon seedlings grown under a 15-hour day, supplemented with fluorescent tubes, at 25°C and 60 per cent relative humidity. Night temperature and relative humidity were 15°C and 80 per cent, respectively.

Ten to 25 adult *T. erytreae* females were allowed to lay eggs on young citrus shoots for 48 hours, and then removed. Under these conditions, preoviposition lasted 8 to 10 days, egg incubation 7 to 8 days, and nymphal instars, 15 to 18 days, for a total cycle of 30 to 36 days.

Importation of parasites of *T. erytreae.* *Tetrastichus dryi* Waterston was described in Kenya by Waterston (1922). As soon as regular production of *T. erytreae* was underway, 200 male and female adults of the Eulophidae ectoparasite *T. dryi* were imported from Transvaal, South Africa, in December 1974. They were collected in citrus orchards by means of small aspirators. Each insect was individually identified by the white patch on the abdomen. Fifty to 60 sweet orange leaves heavily infested with 3rd, 4th and 5th *T. erytreae* instars were also imported. Most of these instars were parasitized. The leaves were imported in sealed boxes and maintained under insect-proof conditions. This material yielded 3,092 *T. dryi,* 51 *Psyllaephagus pulvinatus* Waterston, an Encyrtidae endoparasite, and 6 *Aphidencirtus cassatus* Annecke, a parasite of *T. dryi* and *P. pulvinatus*, which were immediately destroyed.

Rearing the parasites on *T. erytreae.* Nymphs of 4th and 5th instars of *T. erytreae* on young citrus sprouts were

used to rear *T. dryi*. The instars developed within 20 days after egg laying. Ten to 15 adults of *T. dryi* were placed with the nymphs for 24 hours and then removed. After 8 days, the young leaves were cut and placed in small, transparent, aerated boxes. The same procedure was used for *P. pulvinatus*, except that the adults laid eggs on 2nd and 3rd instars. Under these conditions, the life cycle was 10 to 14 days for *T. dryi*, and 20 to 24 days for *P. pulvinatus*. In 24 months, 33,000 *T. dryi* were obtained on 157 citrus seedlings, and 12,500 *P. pulvinatus* were obtained in 16 months on 100 seedlings.

After emergence of these parasites, the mummies of *T. erytreae* are punctured as shown in figure 2.

Release of the parasites in the field. All parasites obtained in the controlled environment room were released in the field regularly two or three times a month, even when no *T. erytreae* were seen in the citrus orchards. The areas of the island that were selected for release were those showing heavy infestations of *T. erytreae* during the flush periods (fig. 1). The releases were always carried out on backyard trees or neglected orchards where no chemical treatments had been applied.

RESULTS

With an original rate of release of 30 to 50 adults per square kilometer of citrus area, *T. dryi* is now well established on Reunion Island 5 years after its introduction. *T. dryi* was found as far as 5-6 km from the release points.

The populations of *T. erytreae* have been so drastically reduced that no chemical control of this psylla appears necessary for the moment. Each new outbreak is immediately reinfested by *T. dryi*.

P. pulvinatus released at an original rate of 15 to 250 adults per square kilometer seems to have disappeared from the island. This endoparasite appears to be much less vigorous than *T. dryi*.

BIOLOGICAL CONTROL OF *DIAPHORINA CITRI*

After eight trials with 200 nymphs of *D. citri* it was evident that *T. dryi*, although excellent for control of *T. erytreae*, was unable to parasitize *D. citri*. Thus, the Eulophidae ectoparasite, *Tetrastichus radiatus* Waterston, described from Punjab, India, on *D. citri* by Waterston in 1922, was collected.

Importation and rearing of *T. radiatus*. In April 1978, the state of Punjab, India, was surveyed for *T. radiatus*. Although orchards were heavily infested with the oriental psylla at the time of the survey, no adults of *T. radiatus* could be seen *in situ*. However, nymphs of *D. citri* examined under the microscope showed signs of parasitism. Since *D. citri* nymphs live on very young flushes and occasionally on stems, we collected sections of woody twigs carrying young, 1- to 2-cm-long sprouts with nymphal colonies. This material was placed in sealed boxes and carried in a polystyrene container at 8 to 10°C. Upon arrival on Reunion, 300 *D. citri* nymphs were examined of which 25 were parasitized by *T. radiatus* and 32 by several endoparasites (probably three species of *Psyllaephagus*). All the endoparasites were killed before species identification was carried out.

From an original population of eight adults of *T. radiatus*, 5,000 of these Eulophidae were obtained within 7 months. The life cycle of *T. radiatus* was only 9-12 days. Its biological characteristics are very similar to those of *T. dryi*. Mummies of *D. citri* showed punctures similar to those of *T. erytreae* (fig. 3). Figure 4 shows a pupa of *T. radiatus* within the mummy of a *D. citri* nymph.

The rearing of *D. citri* was conducted on citrus seedlings in a screenhouse under ambient temperature and humidity. Fluorescent lights were placed 10 cm above the seedlings and were illuminated for 12 hours a day.

Release of *T. radiatus* in the field. A total of 4,600 adults of *T. radiatus* were released in the field at 13 different points (fig. 1). The release took place in backyard trees or in neglected orchards

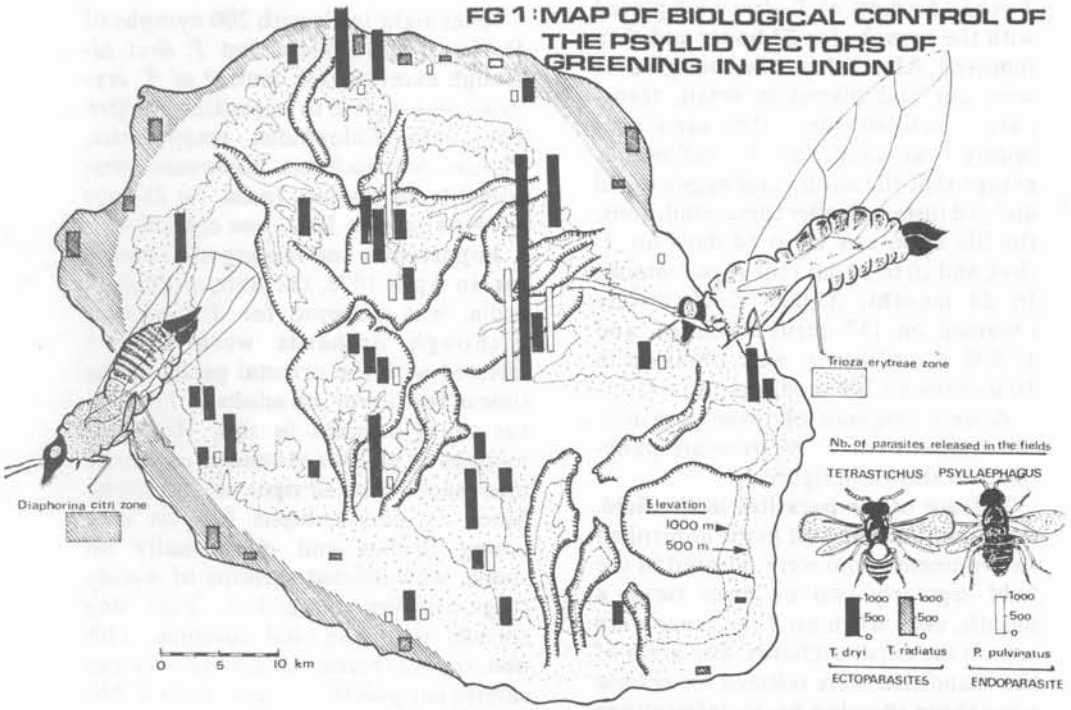

Fig. 2. Punctured mummy of *Trioza erytreae* (X33) after parasitism by *Tetrastichus dryi due to reduction.*

***Fig. 3. Punctured mummy of D. citri* after parasitism by *Tetrastichus radiatus* (X 33).**

Fig. 4. Pupa of *T. radiatus* within the mummy of a *D. citri* nymph (X33).

on the leeward side of the island where *D. citri* is prevalent.

Although preliminary results seem encouraging, it will take at least 1 more year before definite conclusions on the biological control of *D. citri* can be drawn.

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