

Distribution of the Citrus Greening Disease Vector (*Diaphorina citri* Kuw.) in Nepal and Attempts to Establish Biological Control

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ABSTRACT. In Nepal, the Citrus greening disease (CGD) is spread by the Asian vector *Diaphorina citri* Kuwayama. This vector was found recently in the low plains of Terai, after having been previously described in the high valleys of Pokhara, Kathmandu, and Dang. A parasite of *D. citri*, *Tetrastichus radiatus* Waterston, was also observed in the Eastern Terai. This chalcidoid insect, found for the first time in Nepal, was successfully reared under screenhouse conditions in Pokhara without its attendant hyperparasites. A mass rearing program for releasing *T. radiatus* in the contaminated high valleys has been initiated.

Citrus greening disease (CGD) is the primary cause of citrus decline in the high valley of Pokhara and its vicinity (11, 14, 15, 16, 17). *Diaphorina citri* Kuwayama is known to be an efficient vector of CGD in Southeast Asia, the Middle East and Reunion (1, 4, 5, 6, 8, 10). The presence of *D. citri* in the Pokhara valley was reported more than 20 yr ago (7, 13), and populations have recently reached high incidence; an average of 18 adults per twig were observed in certain orchards (14).

Citrus spp. and *Murraya paniculata* have been reported as preferred host plants for *D. citri* in dry climates (1, 4, 8, 10, 12). The strategy of integrated pest management (IPM) was developed successfully in Reunion and Mauritius (Indian Ocean islands) for controlling in the Asian CGD vector (2, 3, 9).

In this paper, the results of a survey conducted in different districts of the country to determine the distribution of *D. citri* and its parasites are presented. Percentages of parasitism obtained on *D. citri* and nymphs with *Tetrastichus radiatus* are also presented.

MATERIALS AND METHODS

A survey of *D. citri* vectors was carried out in Morang, Sunsari, Dhanakuta, Saptori, Siraha, Dhanusa, Mahotari, Sarlahi, Rautahat, Bara, Parsa, Chitwan, Kathmandu, Sinduli,

Dhading, Gorkha, Lamjung, Tanahun, Kaski (Pokhara), Syangja, Pyuthan, Dang, and Salyan districts during the spring flush of 1986. Citrus orchards and other rutaceous plants were examined thoroughly for the presence of psyllid vectors, by collecting adults with a mouth aspirator, following a technique previously described (2). At the same time, nymphs of *D. citri* were also examined with a hand lens for the presence of parasites. Parasitized nymphs were collected and put into hatching boxes and brought to Pokhara within a day of collection. After 3-4 days' incubation, hatched parasites were examined under the light microscope for hyperparasites. To confirm the identity of *T. radiatus*, some individuals were dispatched to taxonomists of the British Museum of Natural History (BMNH). Upon confirmation of identity, *D. citri* were reared on citrus and *M. paniculata* seedlings under screenhouse conditions at Pokhara Horticulture Research Station (935 m), and subsequently inoculated with a few adults of *T. radiatus*.

RESULTS AND DISCUSSION

The survey revealed *D. citri* in abundant numbers (20-25 adults/5 min of aspiration) on *Citrus* and *M. paniculata* host plants in Terai districts Morang, Sunsari, Saptari, Siraha, Dhanusa, Mahotari, Sarlahi, Rautahat, Sinduli, Chitwan, Dang,

Pyuthan, Salyan, Bara, and Parsa. Since the altitude of these districts ranges from 100-700 m above sea level and the climate is dry, this area is most suitable for *Diaphorina citri*. The average number recorded in Pokhara reached 8-10 adults/5 min aspiration, whereas the number of *D. citri* was very low (not more than 5 adults/5 min aspiration) in some pocket areas of the Kathmandu and Dhading districts. The presence of *D. citri* in the Kathmandu valley at 1350 m elevation shows the adaptation of the insect in cooler areas, but *D. citri* was not found in the Dhankuta, Gorkha, or Lamjung districts.

T. radiatus was obtained only from the Eastern Terai. There were clear symptoms of parasitism on *D. citri* nymphs of third, fourth and fifth instars with the typical exit hole on the thorax of the nymph's exoskeleton. Adult individuals of *T. radiatus* were easily identified by morphological characteristics. A weak predator of the *Allographa* type was also recorded in Pokhara. Concurrently, several Coccinellidae were noticed on *D. citri* nymphs, in the same valley. However, in this area, predators were unable to reduce the populations of *D. citri* significantly on spring flushes, hence the necessity of developing new IPM techniques.

The results of rearing *T. radiatus* on six different plant species are given in table 1. The experiment was conducted in the greenhouse in Pokhara at ambient conditions of temperature and relative humidity (14). Sweet orange and mandarin gave the highest percentages of parasitized nymphs, followed by lime and lemon. On *M. paniculata*, *T. radiatus* has established itself less efficiently; confirming observations carried out in

TABLE 1
BIOLOGICAL CONTROL OF THE
CITRUS PSYLLID, *DIAPHORINA CITRI*
BY *TETRASTICHUS RADIATUS* IN
POKHARA UNDER GREENHOUSE ON
SIX DIFFERENT PLANT SPECIES

Species	No. of <i>D. citri</i> nymphs	Parasitism (%)
Sweet orange	215	93.3
Mandarin	65	91.3
Lemon	19	78.9
Lime	15	80.0
Trifoliolate orange	9	66.6
<i>Murraya paniculata</i>	5	40.0

cool areas of Reunion with *M. paniculata* as plant host.

The result of the experiment on biological control under greenhouse conditions seemed encouraging as the percentage of the parasitism exceeded 90% in the case of mandarin and oranges (table 1). No hyperparasites were observed in our collected materials. These facts suggest that there is a good prospect of biological control, at least in Pokhara, Syangja, Sinduli (Madi), and Kathmandu, where *D. citri* is thriving so far without known parasites.

We intend to rear more *T. radiatus* for release in the traditional orchards which have become badly affected by CGD since the 1960's.

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