

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

T. K. Lama, C. Regmi and B. Aubert

**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.

#### ACKNOWLEDGMENT

This research project is supported by the United States Agency for International Development, and the Royal Nepal Academy of Science and Technology. We are also grateful to the Department of Agriculture, HMG/Nepal and to Dr. R. K. Raut and Mr. N. P. Ghimire of the Horticulture Res. Station, Pokhara for providing necessary facilities and for reviewing this manuscript.

#### LITERATURE CITED

1. Aubert, B.  
1986. *Trioxa erythrae* (Del Guercio) and *Diaphorina citri* Kuw (Homoptera): the two Citrus psyllid vectors of the greening disease. Possible strategies of control. Doc. IRFA/CIRAD Reunion, 25 pp.

2. Aubert, B., and S. Quilici  
1984. Biological control of African and Asian citrus psyllids (Homoptera:Psylloidea) through Eulophid and Eneurybid parasites (Hymenoptera:Chalcidoidea) in Reunion Island, p. 100-108. *In Proc. 9th Conf. IOCV. IOCV, Riverside.*
3. Aubert, B., and S. Quilici  
1986. Monitoring adult psyllas on yellow traps in Reunion Island, p. 249-254. *In Proc. 10th Conf. IOCV. IOCV, Riverside.*
4. Bove, J. M., and B. Aubert  
1984. Report on virus and virus like diseases of Citrus in Saudi Arabia, with special reference to Citrus Greening. FAO Rep. 33 pp.
5. Capoor, S. P., D. G. Rao, and S. M. Viswanath  
1967. *Diaphorina citri* Kuw, a vector of Greening disease of Citrus in India. *Indian J. Agr. Sci.* 37: 572-576.
6. Capoor, S P., D. G Rao, and S. H. Viswanath  
1974. Greening disease of citrus in the Deccan Trap Country and its relationship with vector *Diaphorina citri* Kuw, p. 43-49. *In Proc. 6th Conf. IOCV. Univ. Calif., Div. Agr. Sci., Richmond.*
7. Catling, H. D.  
1968. Report of a visit to Nepal. FAO Rep. PL.T/ 67/2 (mimeograph).
8. Catling, H. D.  
1970. Distribution of the psyllid vectors of Citrus Greening disease with notes on the biology and bionomics of *Diaphorina citri* Kuw. *Plant Prot. Bull. FAO 18, No. 1, p. 8-15.*
9. Etienne, J., and B. Aubert  
1980. Biological control of psyllid vectors of Greening disease in Reunion Island, p. 118-121. *In Proc. 8th Conf. IOCV. IOCV, Riverside.*
10. Husain, M. A., and L. D. Nath  
1927. Citrus psylla *Diaphorina citri* Kuw. *Mem. Dept. Agr. (Ent. Serv.), 10(2), p. 5-27.*
11. Knorr, L. C., S. M. Shah, and O. P. Gupta  
1970. Greening disease in Nepal. *Plant Dis. Rep.* 59: 1092-1095.
12. Mathur, R. N.  
1975. Psyllidae of the Indian subcontinent. *Indian Council Agr. Res. New Delhi, 428 pp.*
13. Rana, P. N., and K. C. Sharma  
1965. Preliminary list of crop pests in Nepal. *Tech. Doc. FAO Plant Prot. Comm. S. E. Asia, No. 49, 6 pp.*
14. Regmi, C., and T. K. Lama  
1986. Greening incidence and Greening vector population dynamics in Pokhara, p. 238-242. *Proc. 10th Conf. IOCV. IOCV, Riverside.*
15. Shah, S. M., and L. C. Knorr  
1971. World citrus problems. V. Nepal. *FAO Plant Prot. Bull.* 19(4): 1-8.
16. Lama, T. K.  
1982. Screening of different species/cultivars of Citrus for Greening marker substance. *Inst. Agr. and Animal Sci. J.* 3: 43-45.
17. Thrower, L. B.  
1986. Report on visit to Nepal. FAO Report PL.T/51 (mimeograph).