INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
1560–8530/2007/09–2–329–332
http://www.fspublishers.org

Sampling and Distribution Pattern of Citrus Rust Mite, *Phyllocoptruta oleivora* Ashmead (Acari, Eriophyidae) Using Adhesive Tape Method

S. AGHAJANZADEH[1] AND B. MALLIK
Department of Entomology, University of Agricultural Sciences, GkVK, Bangalore -560065, India; Present address: Iran Citrus Research institute, P.O. Box 46915-335, Motahari St. Ramsar, Mazandaran, Iran
[1]Corresponding author's e-mail: sirous_in@yahoo.com; Tell: + 981925229081; Fax: + 981925223282

ABSTRACT

In order to evolve a better sampling technique for citrus rust mite, *Phyllocoptruta oleivora* Ashmead, an adhesive tape method was evaluated. The number of citrus rust mite counted following this method or by direct counting of the mites on citrus fruits was not different. As the mites were trapped motionless on the adhesive tape, they could be easily counted since these tape were in turn stuck on microscopic slides and observed under high magnification. Further these slides could be stored in a refrigerator for a longer time and observed when convenient. Thus, the adhesive tape method proved easier, more accurate and more reliable than the direct counting method to assess the citrus rust mite population. For studying the population of citrus rust mite adhesive tape method, were used and results revealed that the distribution pattern of the citrus rust mites on the three regions of the citrus fruit (top, middle & bottom) followed a similar pattern. This similarity was also observed between the number of mites on the upper and lower surfaces of leaves. Highest number of citrus rust mites were recorded on fruits in the eastern portion of the tree followed by south, north and west directions. Similarly the leaves in the eastern portion had more mites than the leaves in the other directions.

Key Words: *Phyllocoptruta oleivora;* Citrus; Mite; Sampling; Distribution

INTRODUCTION

The citrus rust mite, *Phyllocoptruta oleivora* (Ashmead) (Acari: Eriophyidae) is an important mite pest of citrus in most of the humid tropical regions of the world and has long been recognized as affecting citrus quality and yield, especially when conditions are optimum and populations explode (Childers *et al.*, 1996, 2005; Aghajanzadeh, 2003). Many methods for sampling or scouting citrus rust mite populations have been described (McCoy *et al*., 1976; Smith, 1980; Allen, 1981; Mora, 1987; Pena & Baranowski, 1990; Hall *et al*., 1991, 1994). Of these, three general approaches to the measurement of citrus rust mite populations on leaves and/or fruit are in widespread use: (1) % infestation measurements, (2) qualitative rating scales and (3) individual adult mite counts. % infestation measurements, although rapid are insensitive to seasonal variations in mite population density (particularly on fruit) resulting in the application of pesticides, when actual numbers may be declining or below injury thresholds (McCoy *et al*., 1976). Qualitative rating scales for estimating rust mites (such as low, medium & high) are subjective and pose the same problems as % infestation measurements. Individual counts, although more accurate and preferred for ecological research (Hall *et al*., 1991) are time-consuming and impractical when confronted with citrus rust mite that exhibits a rapid rate of increase in the spring and summer and when many leaves and fruits must be sampled over thousands of acres per day.

Yothers and Miller (1934) made a counting template (0.5" square) cut in a piece of paper to sample the citrus rust mite. Allen (1976) and Hall *et al.* (1991) estimated densities of citrus rust mite on citrus fruit using a 10X hand lens mounted over a piece of clear plastic etched with a one cm^2 grid. The grid was divided into 25 equal sub-division each having an area of 4 mm^2. Hall *et al.* (1994) used two systematic sampling designs, an area plan and a transect plan to estimate population densities of citrus rust mite motile stages on fruits of Valencia and Hamlin orange trees. The sample unit and counting of citrus rust mite was similar to that mentioned above. Rogers *et al.* (1994) used standardized visual comparison keys to estimate population densities of citrus rust mite with a 10X hand lens. In this method based on the modified Horsfall-Barratt system for the measurement of plant disease, they have used the coded values 0 through 6 for population densities of citrus rust mite, respectively on fruit or leaf 0, 0 - 3, 3 - 6, 6 - 12, 12 - 25, 25 - 50 and > 50.

Population of citrus rust mite sampled from terminal flush of grape fruit leaves differed in the various quadrants of the trees from which they were collected. *P. oleivora* was found to be more numerous on the east as well as the north quadrants of the tree during eight months of the year. In a sulfur dusted grove, citrus rust mite was more numerous on

the east qudrants (Dean, 1959). Allen and McCoy (1978) found more number of citrus rust mites on the bottom northern aspect of grape fruit tree. Shivaraju (1990) reported more number of mites on the northern aspect of the canopy followed by east, south and western aspects, the corresponding figures being 32, 31, 20 and 17%.

During the summer, citrus rust mites are more abundant on fruits and foliage on the outer margins of the tree canopy, generally the north bottom section of the tree is preferred and supports the highest mite populations. The least favorable conditions for citrus rust mite increase are found in the south top of the tree canopy. Citrus rust mites over winter on all tree parts. In the spring the mites migrate to the spring flush, where they feed and begin to reproduce on the leaves. They move to young fruits as they become available, usually in mid-April. Throughout April and May citrus rust mite population remains higher on leaves, but in June, population is higher on fruits (Knapp, 1994). Bergh and McCoy (1997) observed that there was no consistent effect of campass direction on trap-catch of citrus rust mites among three groves. Analysis of data showed significant difference among compass direction at two of these orchards and most mites were captured in traps facing east and west.

The present study attempted to assess the citrus rust mite population by a easier and more accurate method for individual mite counts and it's distribution pattern on leaves and fruits of citrus in different directions of tree.

MATERIALS AND METHODS

Sampling technique for citrus rust mite. In order to evolve a better sampling technique so that population sampling is un-biased and the method is simple an adhesive tape method was evaluated. In this method, to begin with the number of mites in three spots, each of one square centimeter on the mosambi fruits (*Citrus reticulata* Blanco var. *sinensis*), were counted under a stereo binocular microscope, following this an adhesive tape was pasted gently on these fruits. The tape with the mites sticking to it was then separated from the fruit and pasted on a microscopic slide. The citrus rust mites on the slide were counted under a phase contrast microscope. The number of mites in three spots on the slide, each of one cm^2, was counted. This procedure was repeated for 100 fruits collected on three different dates. The data were analyzed statistically following paired sample t-student test.

Distribution of citrus rust mite. For studying the population distribution of citrus rust mite, a private citrus orchard having about 9 years old plants in Bangalore India, was selected. The orchard had 90 trees of two varieties including orange (*Citrus aurantium* L.) and mosambi. Among these nine trees, which were of uniform age and growth pattern, were selected and numbered for the study. Each tree was visually divided into four quadrants viz., north, south, east and west. Samples on leaves and fruits were taken from each quadrant on leaf following the adhesive tape method described above. The population densities of the mite on top, middle and bottom portions of each fruit and also on upper and lower surfaces of leaf were recorded.

The data were subjected to $\sqrt{X + 0.5}$ transformation and analyzed following the ANOVA technique and the results were interpreted at five % level of significance.

RESULTS AND DISCUSSION

Sampling technique for citrus rust mite. There was no significant difference in the number of mites recorded between counting citrus rust mites directly under a stereo binocular microscope and the adhesive tape method (Table I). This indicated that individual counting of citrus rust mites using adhesive tape method offer great accuracy compared to direct counting of citrus rust mites on leaves and fruits under binocular microscope. Although individual counting method of mite population is a time consuming method but it's accuracy, easy counting and storage of slides in a refrigerator for a long time has made it as a good method to assess the citrus rust mite population. As the citrus rust mites were trapped motionless on the adhesive tape, they could be easily counted, especially when they were stuck to the microscopic slides, further these slides could be stored in a refrigerator for a long time and observed as and when convenient. But if the mites have to be counted directly on the fruits error during counting can creep in, since the mites keep moving in and out of the observation area. Thus, the adhesive tape method proved easier, more accurate and more reliable than the direct counting method to assess the citrus rust mite population.

Various methods have been proposed by different authors to count the mite numbers in a unit area. Yothers and Miller (1934) made a counting template (0.5" square) cut in a piece of paper to sample the citrus rust mite. Allen (1976) estimated densities of citrus rust mite on citrus fruit using a 10x hand lens mounted over a piece of clear plastic etched with a one cm^2 grid. The grid was divided into 25 equal sub-divisions each having an area of 4 mm^2. Jeppson *et al*. (1975) have for sampling spider mites suggested a method wherein an imprint of mites present on a leaf is taken by placing the leaf between two papers of proper absorptiveness and by crushing the paper against the mites to get a semi-permanent record of all stages of mite. Individual mite counts, although exact and preferred for ecological research (Hall *et al*., 1991) are time-consuming and impractical when populations increase rapidly in spring and summer and when many leaves and fruits must be sampled over large areas each day. Hence the present method would be very convenient.

Distribution of citrus rust mite. There was no significant defference in the number of mites found on the top, middle

and bottom regions of fruits (Table II). However, there was significant difference in the distribution of the mite in the four different directions of a tree. Highest number of citrus rust mites were recorded on fruits in the east direction (35.73%) followed by south (26.05%), north (23.45%) and least on fruits in the west direction (14.78%) (Table II).

There was no significant difference in the number of mites between upper and lower surfaces of the leaves. Whereas the population of the mite on the two leaf surfaces followed a pattern of distribution similar to that on the fruits with regard to the direction from which the samples were collected. Higher population was recorded on leaf samples from the east direction (56.50%) followed by north (15.86%), south (14.87%) and west (12.77%) directions (Table III).

Allen and McCoy (1978) found more number of mites on the bottom northern aspect of grapefruit tree, Knapp (1994) also reported that the north bottom quadrant of the tree is preferred by citrus rust mite and supports the highest mite populations the least favorable conditions are found in the south top quadrant. These are not in accordance with the present observations, where more mites were observed on fruits in the east direction, this may be due to the geographical differences in the study regions. However, citrus rust mite was found to be numerous on the east as well as the north quadrant of the tree during eight months of the year by Dean (1959). Shivaraju (1990) reported more number of mites on the northern aspect of the canopy followed by east, south and western aspects, the corresponding figures being 32%, 31%, 20% and 17%, which these findings support our observations in present study. But, Bergh and McCoy (1997) observed that there was no consistent effect of compass direction on trap-catches of mites among three groves. Analysis of data showed a significant difference among compass direction at two of these orchards and most mites were captured in traps facing east and west. These results indicate that there can be difference in the number of mites dispersing through wind current landing on a tree and those later establishing on the trees and multiplying on the fruits or leaves. Van Brussel (1975) found that the rust mites prefer lower surface of leaves on very young trees, but the upper leaf surface on trees more than one year old, during the present study both surfaces of the leaves were found harboring mites to the same extent on four years old trees indicating that these mites distribute themselves on all parts of the leaves equally on older plants.

The present results also showed that the number of citrus rust mites on the leaves was less than those on the fruits. Knapp (1994) observed that the mites move to young fruits as they become available, usually in mid April, through April and May mite population was higher on leaves, but in June higher populations became predominant on fruits. In Bangalore, since the fruits were available on the tree throughout the year due to the climatic conditions and the nature of the citrus variety in this study, population of the mite was more on the fruits than on leaves. Similarly, during the fruiting season, Yang *et al*. (1994) found citrus rust mites on fruits, leaves and young twigs, though most mites were found on the fruits.

Table I. Mean number of citrus rust mites in one square centimeter area of the mosambi fruit, by two different methods

Sample No.	Date of observation	No. of fruits	Direct counting method	Adhesive tape method
1.	11.10.2001	20	35.55±37.78	37.85 ± 27.25^{NS}
2.	11.10.2001	20	58.15±37.97	62.65 ± 37.77^{NS}
3.	20.10.2001	20	40.60±32.75	42.50 ± 26.58^{NS}
4.	20.10.2001	20	34.15±20.68	36.20 ± 18.94^{NS}
5.	31.10.2001	20	39.20±27.95	43.85 ± 32.19^{NS}
Mean			41.53±29.97	44.61 ± 29.46^{NS}

NS = Nonsignfiicant at P = 0.05; Figures are averages from three spots on each fruit

Table II. Mean number of citrus rust mites in 1 cm^2 area of the mosambi fruits in different directions of the tree

Fruit region	Tree direction					
	North	East	South	West	Mean	%
Top	53.33	78.67	63.11	37.67	58.19	30.93^{NS}
Middle	55.11	103.44	82.78	37.22	69.64	37.02^{NS}
Bottom	68.67	84.78	50.89	36.77	60.28	32.04^{NS}
Mean	59.04	89.96	65.59	37.22		
%	23.45^{bc}	35.73^{a}	26.05^{ab}	14.78^{c}		

Figures in the table are averages of nine samples.
Means with the same superscript are not significantly different at P = 0.05 according to Duncan's multiple range test; NS = No significant.

Table III. Mean number of citrus rust mites on citrus leaves in different directions of citrus tree

Leaf surface	Tree direction					
	North	East	South	West	Mean	%
Upper	6	20.20	4.22	5.33	8.94	44.70^{NS}
Lower	6.67	25	7.67	4.89	11.06	55.30^{NS}
Mean	6.34	22.60	5.95	5.11		
%	15.86^{b}	56.50^{a}	14.87^{b}	12.77^{b}		

Figures in the table are average of nine samples.
Means with the same superscript are not significantly different at P = 0.05 according to Duncan's multiple range test; NS = No significant.

Acknowledgments. The authors acknowledge the financial support and Ph.D. scholarship by Agricultural Research, Education and Extension Organization, Ministry of Jihad-e-Agriculture, Islamic republic of Iran (to SA) and financial support from Indian Council for Agricultural Research, Government of India (to BM) through NATP.

REFERENCES

Aghajanzadeh, S., 2003. Characterization and mass culturing of some isolates of *Hirsutella thompsonii* (Deuteromycete) and their bio-efficacy against citrus rust mite, *Phyllocoptruta oleivora* Ashmead(Acari: Eriophyidae). *Ph.D. Thesis,* University of Agricultural Sciences Bangalore, India

Allen, J.C. and C.W. McCoy, 1978. The thermal environment of the citrus rust mite. *Agric. Meterol*., 20: 411–25

Allen, J.C., 1976. A model for predicting citrus rust mite damage and Valencia orange fruit. *Environ. Entomol*., 5: 1083–8

Allen, J.C., 1981. The citrus rust mite game: A simulation model of pest losses. *Environ. Entomol*., 10: 171–6

Bergh, J.C. and C.W. McCoy, 1997. Aerial dispersal of citrus rust mite (Acari: Eriophyidae) from Florida citrus groves. *Environ. Entomol*., 24: 256–64

Childers, C.C., M.A. Eastbrook and M.G. Solomon, 1996. Chemical control of eriophyoid mites. *In*: Lindquist, E.E., M.W. Sabelis and J. Bruin (eds.), *Eriophyoid Mites-their Biology, Natural Enemies and Control*, Pp: 695–719. Elsevier sciences publication Amsterdam

Childers, C.C., C.W. McCoy, H.N. Nigg, P.A. Stansly and M.E. Rogers, 2005. *Florida Citrus Pest Management Guide: Rust Mites, Spider Mites and other Phytophagous Mites*, P: 11. University of Florida

Dean, H.A., 1959. Quadrant distribution of mites on leaves of Texas grape fruit. *J. Econ. Ent*., 52: 725–7

Hall, D.G., C.C. Childers and J.E. Eger, 1991. Estimating citrus rust mite (Acari: Eriophyidae) levels on fruit in individual citrus trees. *Entomol. Soc. America*, 20: 382–90

Hall, D.G., C.C. Childers and J.E. Eger, 1994. Spatial dispersion and sampling of citrus rust mite (Acari: Eriophyidae) on fruit in Hamlin and Valencia orange groves in Florida. *J. Econ. Entomol*., 87: 687–98

Jeppeson, L.R., H.H. Keifer and W. Baker, 1975. *Mites Injurious to Economic Plants*, P: 614. University of California Press, Berkeley, California, USA

Knapp, J.L., 1994. *Citrus Rust Mite*, P: 7. University of Florida. *http: /www.edis.ifas.uf l .edu* (accessed 2003).

McCoy, C.W., R.F. Brooks, J.C. Allen and A.G. Selhime, 1976. Management of arthropod pests and plant diseases in citrus agro ecosystems. *Procedures Tall Timbers Conference Ecology Animal Control by Habitat Manage*, 6: 1–17

Mora, M.J., 1987. A new method for sampling of rust mite *Phyllocoptruta oleivora* in an orchard of Valencia trees. *Estacion. Nac. Sanidad los Citricos, Ministerio la Agric. Cent. Agric*., 14: 62–72

Pena, J.E. and R.M. Baranowski, 1990. Dispersion indices and sampling plans for the broad mite (Acari: Tarasonemidae) and the citrus rust mite (Acari: Eriophyidae) on limes. *Environ. Entomol*., 19: 378–82

Rogers, J.S., C.W. McCoy and M.M. Manners, 1994. Standardized visual comparison keys for rapid estimation of citrus rust mite population. *J. Econ. Entomol*., 87: 1–6

Shivarju, B., 1990. Population dynamics, biology and control of citrus rust mite, *Phyllocoptruta oleivora Ashmead. Ph.D. Thesis*, University of Agricultural Sciences, Bangalore, India

Smith, L.R., 1980. Development of extension demonstration work and scouting techniques for citrus rust mites. *J. Rio Grande Valley Hort. Soc*., 34: 67–9

Van Brussel, E.W., 1975. Interrelations between citrus rust mite, *Hirsutella thompsonii* and greasy spot on citrus in Surinam. *Landbouwproefst. Surinam Agric. St. Bull*., 98: 43

Yang, Y., J.C. Allen, J.L. Knapp and P.A. Stansly, 1994. Citrus rust mite (Acari: Eriophyidae) damage effect on Hamlin orange fruit growth and drop. *Environ. Entomol*., 23: 244–7

Yothers, W.W. and R.L. Miller, 1934. Methods for determining rust mite abundance. *Proc. Fla. Soc. Hortic. Soc*., 47: 53–5

(Received 15 December 2005; Accepted 20 July 2006)