The vertical distribution of mites and aphids on hops in southcentral Washington during the summer of 1993.

CENGIZ KAZAK[1], WYATT W. CONE[2], and LAWRENCE C. WRIGHT[2]

[1]DEPARTMENT OF PLANT PROTECTION, FACULTY OF AGRICULTURE UNIVERSITY OF CUKUROVA, 01330 ADANA, TURKEY

[2]IRRIGATED AGRICULTURE RESEARCH AND EXTENSION CENTER WASHINGTON STATE UNIVERSITY, PROSSER, WASHINGTON 99350

ABSTRACT

The distribution of a predatory mite, *Galandromus occidentalis*, was determined along with its prey, the twospotted spider mite, *Tetranychus urticae*, at five elevations on unsprayed hops grown on a 5-6 m trellis. The prey species was well established at all elevations when the study began on July 20, 1993. The predator did not reach the uppermost elevations sampled until two weeks later. Early in the study whole plant predator:prey ratios were 1:90 or more compared to 1:20 in late August. Counts of hop aphids, *Phorodon humuli* Schrank, were also made. At high densities, hop aphids and resultant honeydew on leaves interfere with mite population development. Aphid densities of 100 or more/leaf occurred during the last three weeks of this study and reduced mite numbers. Identification of predator mites indicated ca 6% were *Amblyseius* (=Neoseiulus) *fallacis* (Garmen) which had not previously been reported on hops in Washington.

Key words: Acari, Phytoseiidae, Tetranychidae, Eastern Washington, Humulus, *Phorodon humuli*, *Tetranychus urticae*, *Galandromus occidentalis*.

INTRODUCTION

Hops, *Humulus lupulus* (Urticales:Cannibinaceae), are a specialty crop used for bittering and flavoring beer. Most of the world's hops are produced in Europe (Germany, Czech Republic, and England) and in northwestern U. S. (Washington, Oregon, and Idaho). Two key arthropod pests are the twospotted spider mite (TSSM), *Tetranychus urticae* Koch, (Acari:Tetranychidae) and the hop aphid, *Phorodon humuli* Schrank, (Homoptera:Aphididae). Left uncontrolled, either pest can cause complete loss of the crop. Recent emphasis in most crop systems has been the decreased use of petrochemical-based pesticides and the increased use of natural enemies. A number of predatory insects and mites (Anthocoridae, Coccinellidae, Chrysopidae, and Cecidomyidae) has been recorded from hops (Zelený *et al.* 1981; Cranham, 1982; Campbell and Cone, 1994). Phytoseiid predators of twospotted spider mite are not regarded as viable biological control agents of *T. urticae* in Europe because of the annual nature of the management of the hop crop (Cranham, 1985). Sites and Cone (1985) found *Typhlodromus* (=Metaseiulus)(=Galendromus) *occidentalis* (Nesbitt) dispersed over the hop plant along with its prey, *Tetranychus urticae*, and in an earlier study Pruszynski and Cone (1972) found *Galandromus occidentalis* to be a much better adapted predator on hops than the introduced predator, *Phytoseiulus persimilis*, in Washington.

Hops grow rapidly in May and June and are trained on a trellis 5-6 m high. Little is known about the ability of *G. occidentalis* to forage over the entire hop foliage canopy in search of its

prey, the twospotted spider mite. This study describes the distribution of the two key pests and *G. occidentalis* through one growing season.

MATERIALS AND METHODS

The study was conducted during the 1993 growing season in a block of hops, *Humulus lupulus,* cv. Galena, at WSU-IAREC, Prosser, Washington. The hops were unsprayed. Twenty plants were selected for uniformity and sampled weekly from 20 July to 7 September, 1993 at height intervals of 0-1, 1-2, 2-3, 3-4, and 4-5 m. Three leaves were collected from each plant at each height interval. A pruning pole and ladder were used to pick leaves from the three higher elevations. Samples were returned to the laboratory in plastic bags where mites and aphids were counted under a binocular dissecting microscope (10x). Each leaf was subsampled five times by placing a heavy paper template over it with a 3x3 cm exposed area from which the counts were made. The number of mites and aphids in the five observations per leaf was totaled for each leaf and the mean of these totals was calculated from the three leaves per height for each plant resulting in the number of mites and aphids per 45 cm^2. The mean for each height was then calculated for the 20 plants, resulting in 20 observations per height per date. Counts included eggs and mobile stages of both *Tetranychus urticae* and *Galandromus occidentalis,* and all hop aphids.

Representative specimens of predatory mites were removed from the samples, mounted on microscope slides in Hoyer's fluid, and prepared for identification. A total of 180 slides was prepared.

RESULTS AND DISCUSSION

The mean number of twospotted spider mite, hop aphid, and the predator mite, *Galandromus occidentalis,* per 45 cm^2 leaf area from July to September are in Fig. 1. Mean numbers of each species found at different heights on the plants during the sampling period are plotted in Fig. 2.

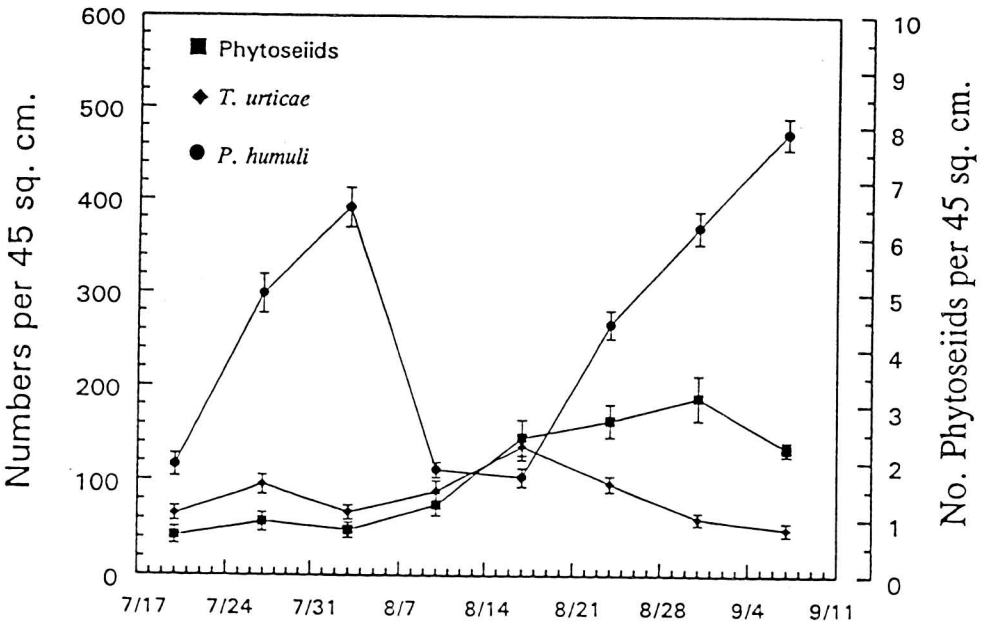

Figure 1. Mean number of aphids (*P. humuli*), spider mites (*T. urticae*) and predator mites (Phytoseiids) per 45 cm^2 subsample per leaf (300 leaves from 20 plants) ± SEM for each date.

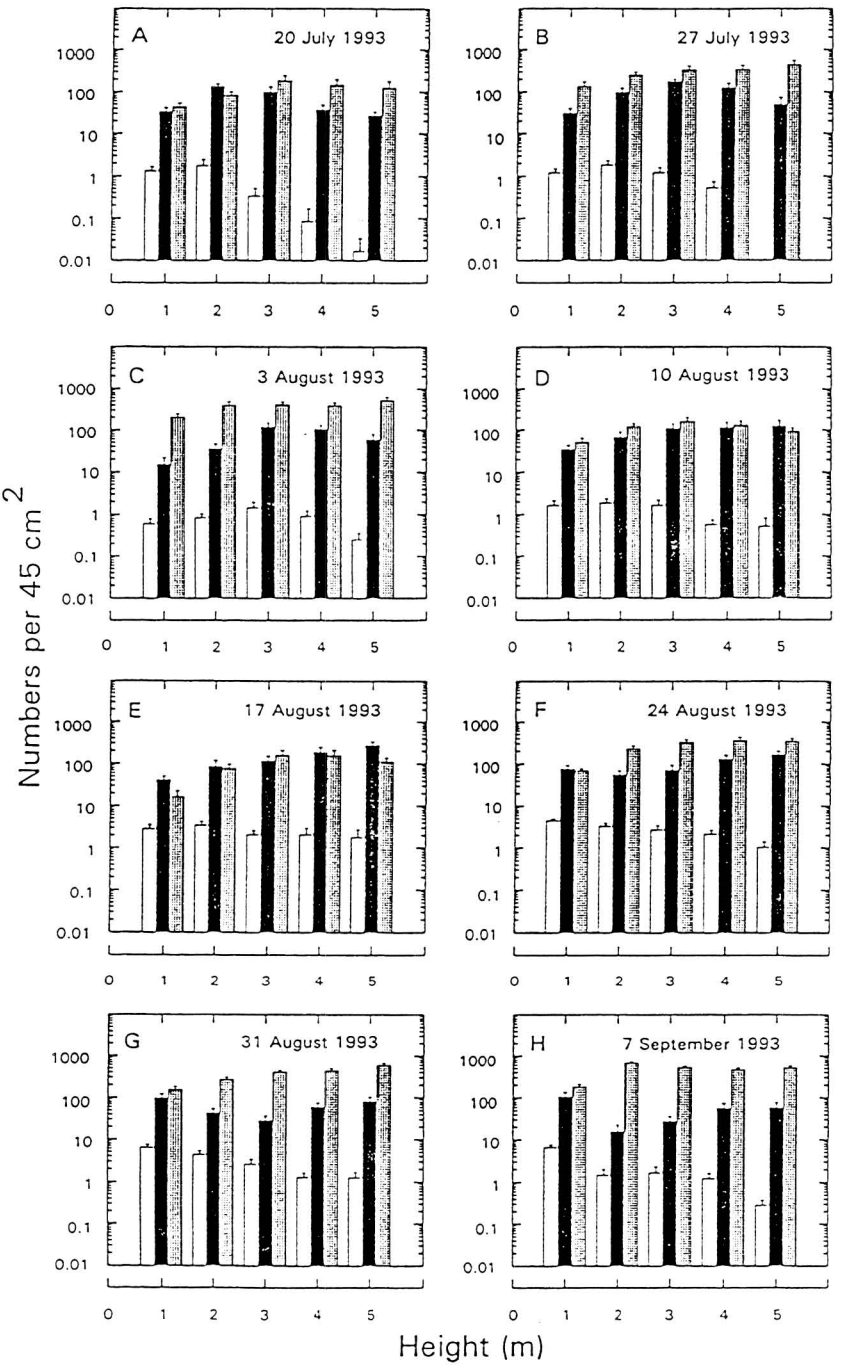

Figure 2. (A-H). Mean numbers ± SEM of *Galandromus occidentalis*, *Tetranychyus urticae*, and *Phorodon humuli* per 45 cm^2 subsample per leaf at different elevations on hop plants, July 20-Sept. 7, 1993. Phytoseiid numbers are represented by the white bar, *T. urticae* by the black bar, and *P. humuli* by the cross-hatched bar

There were two peaks of aphid numbers; one August 3, and the second peak was still increasing when the study ended on September 7 (Fig. 1). Based on field experience, there is usually an increase in aphid numbers in July followed by a sharp decline in numbers with the onset of hot, dry weather. A second increase in numbers usually begins in late August (associated with cooler weather) with peak abundance coming in September. Aphids were least numerous near the ground throughout the study period (Fig. 2).

The twospotted spider mite population showed a small peak in late July and a larger peak in August; these are generally associated with hot, dry weather. In 1993, the peak of TSSM abundance was August 17 (Fig.1). Growth of the predator population, *G. occidentalis,* usually begins slowly but generally follows the prey curve. In 1993 total predator numbers were low (0.70 - 1.24 per 45 cm^2) until August 17 when 2.43 per 45 cm^2 were found. The season peak (3.14 per 45 cm^2) was reached on August 31 (Fig.1).

The first orange (diapause) female TSSM appeared in the population on August 25. The onset of diapause in TSSM is controlled by photoperiod (Veerman, 1985) and triggers a downward migration from the hop plant to overwintering sites. These sites may be plant debris on the soil surface, the hop crown, crevices in the soil or cracks or other openings around the base of wooden hop poles that are part of the trellis.

The distribution of *G. occidentalis* on the hop plant is shown in Figs. 2A-H. TSSM was well established at the tops of the plants when this study began July 20. The number of predators declined with increasing height above the 2 to 3 m heights until August 17 when the numbers among heights were relatively uniform. Predator numbers at the upper elevation (4-5 m) peaked on August 17. After that time (Figs. 2F,G,H) more predator mites were found at 0-1 and 1-2 m elevations, and by September 7 nearly all predators were found close to the ground (0-1 m). This may be a reflection of the foraging ability of the predator following its prey as they move down the plant. The predators do follow TSSM into their overwintering sites (Cone *et al.*, 1993).

The weekly predator:prey ratio was 1:90, 1:104, 1:82, 1:73, 1:61, 1:38, 1:20, and 1:23 during the study period. The actual effectiveness of the predator in reducing TSSM numbers was obscured by the abundance of hop aphids during the last three weeks of the study. Aphids secreted 'honeydew' which seriously interfered with TSSM population development and possibility interfered with Phytoseiid development as well.

Of the 180 slides of predators, 168 were identified as *G. occidentalis* and 12 as *Amblyseius fallacis* (Garmen). *A. fallacis* was the most abundant predator mite reported in a survey of hop yards in Oregon (Strong and Croft, 1993), but this is the first time it has been reported on hops in Washington.

CONCLUSIONS

These data indicate the variation in numbers of pests and predators on hops. The interaction between the two pest species where one (the aphid) by physical means reduces the population of the second (the mite) means that a second type of management may be needed when weather patterns favor aphid development.

These data also indicate that the initial numbers of *Galandromus occidentalis* are too low to maintain *Tetranychus urticae* numbers below their economic threshold.

Partial solutions may rest with the use of selective aphicides that spare natural enemies and with the augmentative release of predatory mites earlier in the season for control of twospotted spider mites. The role that *A. fallacis* plays in the biological control of TSSM on hops in Washington remains to be determined.

ACKNOWLEDGEMENTS

We acknowledge the assistance of M. M. Conant and J. Perez in conducting this study. We are particularly grateful to TÜBITAK, Turkish Scientific and Research Council, for financial support.

REFERENCES

Campbell, C.A.M., and W.W. Cone. 1994. Influence of predators on population development of *Phorodon humuli* (Homoptera:Aphididae) on hops. Environ. Entomol. 23:1391-6.

Cone, W.W., M.M. Conant, and L.C. Wright. 1993. The soil mite fauna of hop crowns. Effect of predators on the overwintering population of twospotted spider mites. In: Proc. Sci. Comm. Int'l. Hop Growers Commission. R.E. Gunn and C.P. Green (eds). Wye College, England. pp. 50-60.

Cranham, J.E. 1982. Integrated control of damson-hop aphid, *Phorodon humuli*, on English hops: a review of recent work. Agric. Environ. 7:63-71.

Cranham, J.E. 1985. Hop. Spider mites, their biology, natural enemies and control. Vol. 1B. World

Pruszynski, S. and W.W. Cone. 1972. Relationship between *Phytoseiulus persimilis* and other enemies of the twospotted spider mite on hops. Environ. Entomol. 1(4):431-33.

Sites, R.W. and W.W. Cone. 1985. Elevational dispersion of twospotted spider mites on hops throughout the growing season. J. Entomol. Soc. Brit. Columbia 82:22-25.

Strong, W.B. and B.A. Croft. 1993. Phytoseiid mites associated with spider mites on hops in the Willamette Valley, Oregon. J. Entomol. Soc. Brit. Columbia 90:45-52.

Veerman, A. 1985. Diapause in spider mites, their biology, natural enemies and control. Vol. 1A. W. Helle and M.W. Sabelis (eds). Elsevier. pp 279-310.

Zelený Jr., I. Hardý and P.K. Kalushkov. 1981. Population dynamics of aphid and mite predators in hops: Bohemian hop-growing area. Int'l. Org. Brewing Chemists/WPRS Bull. 1981, 4:87-96.