CHEMICAL AND BIOLOGICAL CONTROL OF ERYTHRONEURA LEAFHOPPERS ON *VITIS VINIFERA* IN SOUTHCENTRAL WASHINGTON

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ABSTRACT

Fenpropathrin (56 g [AI]/ha) and dimethoate (1681 g [AI]/ha) controlled the western grape leafhopper, *Erythroneura elegantula* Osborn. Arthropod predators were collected on wine grapes, *Vitis vinifera* (L.). Most were of uncertain importance in the regulation of *Erythroneura* spp. populations. The greatest source of leafhopper egg mortality is parasitization by the mymarid wasp, *Anagrus epos* Girault. Vineyards grown in isolated areas (10-20 Km from other irrigated areas) are subject to leafhopper injury in the absence of the parasitoid which requires a continuous supply of leafhopper eggs. The concept of infesting French prune, *Prunus domestica* L., with non-pestiferous *Erythroneura prunicola* as a winter refugium for *A. epos* is advanced as an approach to biological control of *Erythroneura* spp. in isolated areas.

KEY WORDS: *Erythroneura elegantula, Erythroneura ziczac, Vitis vinifera, Anagrus epos,* parasitoid, leafhopper control, wine grape pest management

INTRODUCTION

Control of the western grape leafhopper (WGLH), *Erythroneura elegantula* Osborn, has been investigated extensively for many years, particularly in California. Excessive application of pesticides to control WGLH in California led to both insecticide resistance in the leafhopper (Doutt and Smith 1971) and tetranychid mite outbreaks (Flaherty and Huffaker 1970). Problems from unnecessary sprays were avoided after it was established that Thompson seedless vines grown for wine production suffered no economic loss from a mean of 20 first generation nymphs per leaf and 10-15 second and third generation nymphs per leaf (Jensen *et al.* 1969). Most Washington wine grape growers use these threshold levels. Pacific Northwest Extension recommends parathion, demeton, azinphosmethyl, oxydemetonmethyl, or phosdrin for control of "leafhoppers" on Vitis spp. (Capizzi *et al.* 1987). In addition, dimethoate is registered for leafhopper control in Washington. The British Columbia Ministry of Agriculture recommends carbaryl, azinphosmethyl, or endosulfan for control of Virginia creeper leafhopper (VCLH), *Erythroneura ziczac* Walsh, on Vitis spp. (J. Vielvoye 1985 pers. comm.).

Jensen and Flaherty (1981) listed several WGLH predators and parasitoids. Although many predators and parasitoids are known in the Pacific Northwest, the association of these beneficial arthropods with young wine grape vineyards in isolated areas of the region has not been determined. Since 1982, Washington wine grape pest management specialists have found parasitized WGLH eggs and suspected the mymarid wasp *Anagrus epos* Girault. This species attacks a variety of typhlocybine leafhoppers including *Typhlocyba pomaria* McAtee, *T. quercus* (F.), *Edwardsiana prunicola* (Edwards), *E. rosae* (L.), *Erythroneura plena* Beamer (Mulla, 1956); *Dikrella cruentata* (Gillette), *E. elegantula* (Doutt and Nakata 1973); *Dikrella californica* Lawson (Williams 1984); and *E. ziczac* (McKenzie and Beirne 1972).

Girault (1911) described *A. epos* from a specimen collected on a windowpane in Illinois. Mulla (1956) illustrated the immature forms. *A. epos* completes about three generations for every one of the WGLH (Doutt and Nakata 1973) and had an intrinsic rate of increase about twice that of the leafhopper (Williams 1984). *A. epos* parasitism reached 70% in samples of VCLH eggs in British Columbia (McKenzie and Beirne 1972). Cate (1975) observed that parasitism in two California vineyards increased from 7.5 and 23.4% of first generation WGLH eggs, to 70 and 88% in late season.

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Doutt and Nakata (1973) first considered using *A. epos* regulation of WGLH to reduce pesticide applications that were triggering pesticide resistance and spider mite outbreaks.

The purpose of this study was: 1) to evaluate insecticides for control of *Erythroneura* leafhoppers on *Vitis vinifera* (L.), 2) to determine the presence of predators or parasitoids and their influence on leafhopper density, and 3) to determine if economic leafhopper injury is associated with isolation from *A. epos*.

MATERIALS AND METHODS

Pesticide evaluation. In 1984, a commercial Riesling vineyard was used to test the effect of dimethoate on a mixed population of WGLH and VCLH. The vineyard rows ran north-south. The 10 rows on the west edge were left unsprayed. Two unsprayed plots of 25 and 29 vines were established at the northwest and southwest corners of the vineyard, respectively. Five unsprayed rows were left between the control plots and the sprayed vines. Two sprayed plots of 30 vines were established, one at the north and one at the south edge of the sprayed vines. Dimethoate 25% wettable powder (WP) was applied on 30 June using a Degania^{R} sprayer operating at 23,000 g/cm^2 at a rate of 1702.5 g (AI) in 470 liters H_2O/ha. Four rows were treated with each pass.

Erythroneura spp. population density was sampled without replacement by counting the number of nymphs on the underside of one shaded leaf picked from each of 30 vines.

Table 1. Mean number of *Erythroneura* spp. nymphs underside of *V. vinifera* var. Riesling leaf treated with dimethoate 25% WP[a], Cold Creek, Washington, 1984

Days post-application	untreated (n=54)	treated (n=60)
- 1	22.3	28.7
7	5.8	0.1
19	0.9	0.1
26	0.9	0.0
33	0.3	0.0
40	0.1	0.0
47	0.8	0.0
57	0.8	0.1
61	1.4	0.0
69	0.6	0.8
75	0.2	0.2
82	0.2	0.2
89	0.1	0.1
96	0.0	0.1

[a] 1702 g (AI) applied in 470 liters H_2O/ha.

In 1985 and 1986, plots were established in a block of Chenin Blanc grapes located at Washington State University, Irrigated Agriculture Research and Extension Center (WSU-IAREC), Prosser, WA. Plots consisted of six vines and were replicated four times in a randomized complete block design. In 1985, dimethoate, fenpropathrin and cloethocarb were evaluated. Rates are listed in Table 2. Treatments in 1986 included dimethoate and fenpropathrin (rates listed in Table 3). Pretreatment counts were made 1 August (1985) and 8 July (1986). Applications were made 5 August (1985), 15 July and 22 August (1986) using an air blast sprayer operated at 21,000 gm/cm^2. Plot rows were sprayed from both sides using a total volume of 1870 l H_2O/ha. Cross row contamination was avoided by using only the nozzles on one side of the sprayer with the spray directed against a canvas shield, 2.6 m high and 3.7 m long, pulled by a tractor in the adjacent row (Grimes and Cone 1985).

WGLH population density was sampled with replacement by counting the number of nymphs on the underside of 10 leaves, approximately breast height, from each of six vines per plot 1985 and 1986. Data were subjected to analysis of variance and means were compared using Duncan's multiple range test (Duncan 1955).

Table 2. Effect of pesticides on WGLH on *V. vinifera* var. Chenin blanc, IAREC, Prosser, WA 1985. Mean number nymphs/underside of 60 leaves

Treatment	Rate (g AI/ha)[a]	Mean number nymphs 4 days post-application[b]	Mean number nymphs 24 days post-application
Unsprayed	----	16.0 a	11.0 a
Cloethocarb 50% WP	141.9	4.5b	9.8ab
"	233.8	1.3b	5.3ab
"	567.5	0.0b	3.3b
Dimethoate 25% WP	2270.0	0.8 b	5.0ab
Fenpropathrin 2.4% EC	227.0	0.0b	3.3b

[a] All materials were applied in 1870 liters H_2O/ha.
[b] Column means followed by the same letter are not significantly different DMRT, $P < .01$.

Survey for arthropod predators and parasitoids. Leaf and sweep net samples were collected from *V. vinifera* grapes during the 1983 and 1984 growing seasons at WSU-IAREC and Cold Creek, WA. Leaf and sweep net samples were taken in September and October 1984 from 12 vineyards throughout southcentral Washington. At least 50 m of each vineyard margin was sampled with a sweep net and a minimum of 200 leaves sampled from each location at each sampling date. Leaves were examined for the presence of *Erythroneura* immatures and evidence (see methods under *Anagrus parasitism*) of *A. epos*. The sweep net samples were sorted for predators or parasitoids which were pinned, labeled and prepared for identification. Cicadellidae species were determined using the keys of Oman (1949) and Beirne (1956). Other specimens were sent to appropriate authorities for identification (see acknowledgment). Voucher specimens were placed in the M. T. James Insect Museum at Washington State University, Pullman.

Anagrus parasitism. Two vineyards observed to have high numbers of *A. epos* were sampled for their incidence of egg parasitism. One hundred shaded leaves were picked from WGLH infested vines 3.2 km north of Grandview, WA on 4 October 1984, and from caged and uncaged Grenache vines with both WGLH and VCLH at IAREC on 27 September 1984. The cages had been installed in July using saran screen of 12.5 X 12.5 strands/cm^2 (Bioquip Corp. El Segundo, CA). The effect of the cages on *A. epos* movement was unknown. The sampled leaves were examined under a dissecting microscope (20X). To determine the incidence of parasitism, eggs containing visible *Anagrus* larvae were counted as parasitized. Young *A. epos* larvae just beginning develpment in its *Erythroneura* host cannot be recognized so those eggs were not counted as parasitized. In addition, emergence holes in leaf tissue were counted. Wasp emergence holes were circular whereas normal leafhopper emergence left a narrow slit in the leaf tissue (Fig.1). The difference between the circular holes and the narrow slits provided a clear postemergence method for distinguishing between normal and parasitized eggs. Since only *Anagrus epos* were recovered from reared material, we assumed the emergence holes to be produced by that species.

RESULTS AND DISCUSSION

Pesticide evaluation. The mean number of *Erythroneura* spp. nymphs per leaf on vines treated with dimethoate in 1984 are compared with untreated vines (Table 1). *Erythroneura* nymph density dropped dramatically and remained low in both the sprayed and unsprayed plots. Pesticide drift into the control plots was observed at the time of application and may have caused the drop in nymphal density observed in all experimental plots. Although nymph density was low in both treated and untreated areas, numbers were slightly higher in the untreated area after 7 days and remained slightly higher throughout the test period. Nymphal density on nearby untreated Grenache vines increased during the same period until the vines were defoliated.

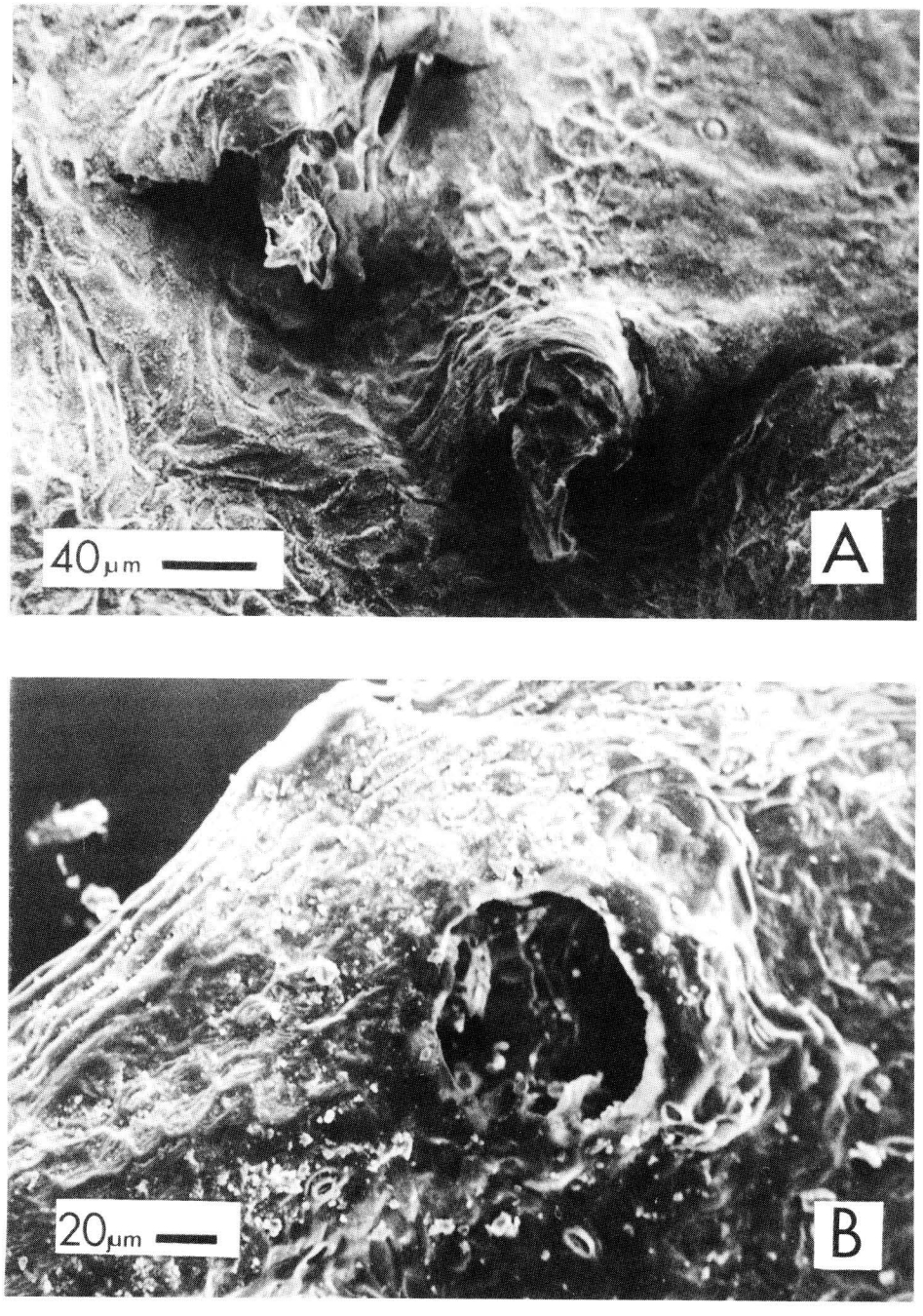

Figure 1. SEM of *Vitis vinifera* leaves comparing the slit-like, normal emergence hole of western grape leafhoppers (A) and the circular hole of its parasitoid *Anagrus epos* (B).

The mean number of WGLH nymphs per 60 leaves in each treatment in 1985 is given in Table 2. Four days post-treatment, nymphal density was significantly lower in all pesticide treated plots compared with unsprayed plots. Twenty-four days post-treatment, only vines sprayed with fenpropathrin and the highest concentration of cloethocarb (560.7 g [AI]/ha) had nymphal densities significantly lower than the unsprayed vines.

In 1986, three rates of fenpropathrin were compared with dimethoate and an untreated check. Leafhopper nymphs were counted weekly from early July until harvest in September (Table 3). The number of leafhopper nymphs were about equal in all plots on July 8 before the first application was made. Fenpropathrin at 56, 112, and 224 g (AI)/ha provided excellent control of western grape leafhopper. A few nymphs appeared in the plots treated with 56 g (AI)/ha after one month. Plots treated with dimethoate at 1681 g (AI)/ha had reduced numbers of nymphs two days after treatment but they were not significantly different from the untreated check. Nymphs appeared in dimethoate treated plots after one month. A second application was made to treatment plots on August 22 in anticipation of a fall increase and based on increasing numbers in the untreated plots. The fall population increase did not develop.

Survey for predators and parasitoids. Many arthropod predators were found on *V. vinifera* in southcentral Washington (Table 4). An unidentified salticid spider was the only species observed to prey on *Erythroneura nymphs*. Many of the predators found, however, prey on *Erythroneura* spp. elsewhere (Knowlton, 1946; McKenzie and Beirne, 1972; Jensen and Flaherty, 1981) and probably do so in Washington. Hemerobiid adults were found on *V. vinifera* at the end of the growing season, but were not collected in this survey. The mite fauna on *V. vinifera* were not considered, but *Anystis agilis* (Banks), known to prey on WGLH (Jensen and Flaherty 1981), is found on several Washington crops (W. W. Cone, unpublished data). It appears that predation on either WGLH or VCLH is isolated and sporadic with no consistent predator-prey relationships.

Anagrus parasitism. The greatest source of egg mortality for WGLH or VCLH seemed to be parasitization by *Anagrus epos*. No adult or nymphal parasitoids of *Erythroneura* spp. were found in this study. The incidence of *A. epos* parasitism (12 Sept 1984) on uncaged vines at an IAREC vineyard was 83.2% (322 of 387 eggs) and 74% (276 of 373 eggs) at a vineyard 3.2 km north of Grandview, WA. Parasitism of eggs laid in clusters by VCLH or those laid singly by either VCLH or WGLH appeared equal.

Although some vineyards in the study area developed high numbers of *A. epos* late in the season, early season *A. epos* activity is important in regulating WGLH populations (Doutt and Nakata, 1973) and should be investigated more closely in the Pacific Northwest. Since the wasp requires a continuous supply of host eggs, it cannot overwinter in Washington vineyards. Doutt and Nakata (1973) found that vineyards within 3.2 km of natural *Rubus* spp. stands, with their year-round supply of *Dikrella cruentata* eggs, typically did not need chemical control measures. In Washington, vineyards established in desert locations, far from *A. epos*, displayed the worst WGLH problems. Growers close to *A. epos* overwintering sites needed only to recognize that fact and avoid the calendar-dictated spray schedule. In British Columbia, VCLH in vineyards near overwintering refuges such as wild *Rosa* sp. or apple, experienced *A. epos* parasitism one month earlier than vineyards surrounded by desert (McKenzie and Beirne, 1972).

Early efforts to bring wasps to isolated vineyards by planting *Rubus* spp. failed when the interior of the blackberry stands became too dry to support *Dikrella* sp. (Jensen and Flaherty, 1981). This problem may be resolved as horticultural practices are refined (Williams, 1984). Kido *et al.* (1984) found that orchards of French prune, *Prunus domestica* L., orchards with the non-pestiferous *E. prunicola* can supply sufficient *A. epos* to control WGLH in adjacent vineyards.

The concept of establishing winter refuges for *A. epos* may be very useful for biological control of *Erythroneura* spp., particularly where vineyards are isolated from other irrigated areas. Varieties of *Prunus domestica* might be investigated for production of *Erythroneura* spp. and *A. epos* and then planted near isolated *V. vinifera* vineyards where they would serve as an early season source of *A. epos*. Surveys of several Italian prune orchards in the vicinity of IAREC indicated high populations of *E. prunicola*.

Table 3. Mean number of western grape leafhopper nymphs per 10 leaves in plots of Chenin blanc grapes treated with insecticides.[a] WSU-IAREC, Prosser, WA. 1986

Treatment	Rate (g [AI]/ha)	$\bar{x}$ WGLH nymphs/10 leaves[b] 7/8	7/17	7/24	7/30	8/7	8/15	8/20	8/27	9/4	9/10
Fenpropathrin	56	7.8 a	0 a	0 a	0 a	0 a	0.1 a	0.5 a	0 a	0 a	0 a
	112	6.5 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a
	224	7.2 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a
Dimethoate	1681	6.3 a	1.3 b	0.1 a	0 a	0 a	0.2 a	0.3 a	0 a	0 a	0 a
Untreated	--	7.6 a	3.3 b	2.2 a	0.9 a	4.1 b	8.1 b	13.4 b	7.9 b	2.1 b	0.3 a

[a]Treated July 15 and Aug 22, plots replicated four times.

[b]Column means followed by the same letter are not significantly different (DMRT, $P \leq 0.01$).

Table 4. Arthropod predators collected on *V. vinifera* in southcentral Washington, 1984

ARACHNIDA

Thomisidae

Xysticus sp.[a]

Salticidae[a]

Oxyopidae

Oxyopes sp.[a]

Tetragnathidae[a]

Anyphaenidae[a]

Araneidae

Argiope trifaseiuta (Forskal)

COLEOPTERA

Coccinellidae

Hippodamia convergens Guérin-Méneville

Coccinella transversoguttata Falderman

Stethorus punctum picipes Casey

Hyperaspis dissoluta nevadica Casey

NEUROPTERA

Chrysopidae

Chrysopa nigricornis Burmeister

HEMIPTERA

Anthocoridae

Orius tristicolor (White)

Reduviidae

Sinea diadema (F.)

Lygaeidae

Geocoris pallens Stal

Nabidae

Nabis alternatus Parshley

[a] Specimens were immature and could not be identified further.

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