Cobweb Management and Low-risk Sprays as IPM Strategies to Control the Marbled Cellar Spider, *Holocnemus pluchei* (Araneae: Pholcidae)

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Introduction

Many species of spiders produce webs for the function of catching prey. Some synanthropic spiders become nuisance pests around the home when their webs accumulate or gather dust and debris after the spider has vacated the site. Cellar spiders are common around homes. Cellar spider cobwebs are typical nuisance indicators of the spider's occupancy, even being present long after the spider is gone. Because cellar spiders do not remove or recycle their webs as some species do, their webbing tends to accumulate over time in unsightly entanglements, especially under the eaves of houses (Fig. 1). Their webs are sticky, may become matted, and are difficult to remove. Many PMPs recommend web removal to control cellar spiders, but there is no data indicating that web removal reduces the number of spiders present. Unless the spider is killed or removed, they quickly reconstruct their web.

Fig. 1. Underside of eaves and wall around a security light before treatment showing a large number of cellar spider cobwebs. Some webs were old and abandoned but many were occupied.

Cellar spiders belong to the family Pholcidae. Several pholcid species are established throughout the U.S., but the biology of each is similar. For this trial, we studied IPM strategies to control one pholcid in particular, *Holocnemus pluchei* (Scopoli), the most common pest species in the California (Fig. 2). It is native to the Mediterranean region

Fig. 2. An adult cellar spider, *Holocnemus pluchei*.

and the timing of its establishment in North America is not well documented (Porter and Jakob 1990, Jakob 1991). From consensus of arachnological colleagues, it is thought to have been introduced into the San Francisco Bay area in the 1950s and has spread throughout California into Arizona and New Mexico. Perhaps because it is more prolific than other spiders, has few effective predators, resides in refugia not preferred by other species, and because it protects its website aggressively, *H. pluchei* is one of the most common species encountered both inside and outside homes in southern California.

In this study we conducted laboratory and field experiments to examine strategies to control cellar spiders on buildings. The most common current strategy used to control *H. pluchei* involves directly spraying the spiders and their webs with insecticide. Besides determining whether web removal *per se* reduces the prevalence of this spider, we evaluated the activity of some representative insecticides as contact sprays. A priority of our study was to determine whether there may be IPM methods that provide significant cellar spider control for 8 to 12 wks, the general southern California PMP model. Several insecticides are labeled for spider control, but their activity and effectiveness against *H. pluchei* has not been documented. One of our objectives was to determine the extent to which *H. pluchei* was susceptible to low-impact spray strategies. Such strategies minimize risk by using lowest effective % and volume rates. Preliminary tests revealed that some were not active against *H. pluchei* at maximum label rate, while others were active at much lower than maximum rate, suggesting that some insecticides may control this species at lower than label % or volume. Direct contact sprays in the laboratory were made to mimic the field situation where the spiders are directly sprayed in their refugia.

Materials and Methods

Field study

Test Sites and Pre-treatment Census. Treatment sites were designated on multiple outbuildings on the University of California Riverside (UCR) campus in June 2009. There still exist on the campus many neglected buildings which served as storage sheds decades ago. These unkempt wood-sided buildings have conventional overhanging eaves and are situated in remote areas of the campus. We inspected these buildings and found many of them to harbor large numbers of *H. pluchei* and their webs. Because of their isolation, cobweb experiments could be performed on these buildings without interference.

Each treatment replicate consisted of a specific 15 to 24-ft section of a building, from the sheathing above the rafter eaves to the ground. The eaves were 24-in apart and had a 24-in overhang. Each building had an asphalt tile roof. For this study, a replicate section encompassed the length between 8 to 10 rafter eaves. A section was included in the study only if at least 2 live *H. pluchei* spiders were found there. Some buildings had multiple infested sections. For example, one 60 ft by 23 ft building was assigned three 20-ft long sections on the front, three on the rear, and one 23-ft section on each end. We considered the sections to be independent from one another. Each section was considered a mimic of an infested home.

The exposed evenly-spaced rafters made it easy to designate one treatment section from another. A total of 40 sections was selected for study. Each section was given a distinctive label so that we could observe the effect treating that particular section. The exact location and approximate size of each spider and its webbing was noted and the total number of spiders per section tallied.

Each of the sections to be treated was assigned to one of randomly assigned treatments so that the distribution of the number of spiders was similar among the treatments. The designated sections were sorted by a decreasing number of spiders in them. The first five sections were randomly assigned to treatments 1-5. Sections 6-10 were then also randomly assigned to treatments 1-5 and so forth until all the sections were assigned. The result was that each treatment group contained similar numbers of spiders. This kind of sorting is used extensively in cockroach control field experiments where there is often a wide range of pre-count numbers per treatment group.

Treatment. Besides leaving some sections untreated, treatments consisted of 1.) thoroughly brushing the entire under section of overhanging eaves with a Webster cobweb brush equipped with a telescoping extension handle that could reach to about 10-ft (Ettore Products Co., Alameda CA) to remove cobwebs and crush exposed spiders, 2.) removing webs and spiders by vacuuming the entire section with a powerful industrial vacuum (Omega Vac Supreme, Atrix International Inc., Burnsville, MN), 4) spraying with EcoPCO EC-X (maximum label concentration, 1 gal/750 ft^2) as a diluted botanical + 3% pyrethrins concentrate (EcoSMART Technologies, Alpharetta, GA), and 5.) spraying with 0.5% Tengard SFR (maximum label concentration, 1 gal/750ft^2) from diluted 36.8% Tengard concentrate (United Phosphorus, King of Prussia, PA). Fig. 3 shows the Webster brush and vacuum in use to remove cobwebs.

The sprays were applied with at low pressure with a Birchmeier Iris + 15-liter backpack sprayer equipped with a fan nozzle (Stetten, Germany). To assure the label application volume of 1 gal/750 ft^2, the area to be sprayed was measured for each section and the corresponding duration of application needed was timed with a stopwatch. On average, it took 58 sec to spray each EcoPCO EC-X section and 64 sec for each Tengard section. This was remarkably similar. The difference was attributable to the wall area below the eaves of some Tengard sections being taller, therefore requiring slightly more spray. The brushings, vacuuming, and spraying were made 17 - 18 Jun 2009, within 2 d of the pre-treatment census.

Fig. 3. Cobweb removal. *Left*, Webster cobweb brush at end of telescoping extension handle being used to remove cobwebs under an eave; *right*, cobwebs being removed with Omega Vac Supreme.

Effect of Treatment. Each of the sections was carefully visually examined 2 wks and at 1, 2, 3 and 4 mo after treatment in order to determine if an effect of treatment occurred quickly and if the effect persisted. The location and size live spiders was recorded at each census. A dramatic change of location suggests the spiders moved in response to treatment. Similarly, because spiders grow slowly, a dramatic change in the size of the spiders present indicates a new cohort of spider residents. Such a new cohort may result from an infusion of immigrant spiders taking up residence as the original spiders were eliminated. Effectiveness at each census period was calculated from the average number of spiders present compared to the average number present at the pre-treatment census. The size of spiders present in the pre-treatment census and those present 4 wks post-treatment were statistically compared with the Kolmogorov-Smirnov Test (Statistix 9). A significant difference in size within 4 wks indicates they are likely different spiders. Effectiveness of treatment was statistically analyzed with the Kruskal-Wallis Test, a one-way analysis of variance by ranks.

Laboratory Study

Spiders and treatment. We evaluated the activity of selected low-impact sprays against *H. pluchei* to determine whether less than maximum label rates (LR_{max}) would be effective against them. More than 70 *H. pluchei* to be sprayed directly with insecticide were collected from buildings on the U.C. Riverside campus. Individual spiders were kept for up to 4 wk in 4-oz transparent styrene cups capped with paper toweling. Each spider was fed a stunned German cockroach, *Blattella germanica*, approximately weekly. Well-fed captured *H. pluchei* remain healthy for several months. Spray activity was determined after treating a replicated number (n = 5) of individual spiders with 3 pumps of aqueous fan spray from a 0.5-L hand-held pump trigger sprayer held about 15 in away. The spiders were sprayed in the cups in which they were maintained. The spiders were thoroughly treated, spray droplets being obvious on their body and legs. Different concentrations of spray were tested but the volume applied was constant at 1 gal/750 ft^2. Immediately after treatment excess spray was drained from the cup and the spider was transferred to a clean cup provisioned with a 1-3/4-in by 3-in piece of stiff paper. Direct spray rather than surface tests were done because *H. pluchei* remains suspended in its web and rarely contacts surrounding surfaces. Allowing for delayed effect, mortality or irreversible paralysis of each sprayed spider was determined daily for 5 days. The minimum effective dose (MED) was calculated for each % concentration of spray as the concentration below which <100% of the spiders succumbed within 5 days. In the case of EcoPCO EC-X and permethrin, a correlation was made between the contact activity observed in the laboratory and the results observed in the field control trial.

Insecticide sprays. The minimum lethal concentration (MLC) of each of the sprays we used in the field portion of the study was determined and compared to the MLC of some other sprays thought to have the potential for controlling cellar spiders. A formulation containing essential oils + 3.0% pyrethrins (EcoPCO EC-X) for the study was provided by EcoSMART Technologies, Alpharetta, GA. Eco WP-X is another essential oil low-impact wettable powder formulation reportedly used by some PMPs to control spiders, but because of widely inconsistent results we obtained against spiders in preliminary laboratory trials, it was not included in this study. We used the LR_{max} permethrin (Tengard SFR) as a spray treatment in the field portion of this study, but we evaluated much lower rates in the laboratory study. Permethrin and pyrethrins have similar acute effects on insects and spiders. Permethrin has good contact activity and residuality while EcoPCO EC-X has good contact activity by way of its pyrethrins content, but is short-lived. We evaluated the acute activity of pyrethrins as the active portion of Eco PCO EC-X. For comparison Optigard Flex SC, (thiamethoxam, 21.6%) provided by Syngenta, Greensboro, NC was included in the study, as was Temprid SC (imidacloprid, 21.0% - beta-cyfluthrin, 10.5%) purchased from Target Specialty Products, Santa Fe Springs, CA. Aqueous dilutions of the contact sprays were prepared with distilled water.

Results

Field Trials. The number of spiders in the untreated sections increased from June through August and decreased naturally by mid-October when the experiment was terminated. The single permethrin spray had the most dramatic effect, significantly ($P < 0.05$) reducing the number of spiders >90% within 2 wks. Compared to the untreated controls, brushing and vacuuming had an effect, but the effect was minimal and not statistically significant. There were about the same number of spiders before brushing or vacuuming as before treatment, indicating that either many spiders survived treatment (perhaps in cracks or other hiding places) or that immigrant spiders moved into the sections from surrounding untreated areas. Regardless of treatment, during the time of the trial there was no significant difference ($P < 0.05$) between the average size of spider in each section before treatment compared to after.

LR_{max} permethrin (Tengard) spray eliminated cellar spiders rapidly and inhibited reinvasion. At 2 wks there were no spiders in any of the sections sprayed with Tengard and one section remained free of spiders for the entire study. Four other Tengard-treated sections had a maximum of only 1 spider at any census. Although the spiders were killed, most webbing remained intact or as a matted mass. In commercial practice, such unsightly webbing may need to be removed.

The IPM strategy of a single thorough brushing with the Webster brush, complete vacuuming, or spraying with the EcoPCO EC-X essential oil botanical formulation each reduced the number of spiders to levels approximately intermediate between a single permethrin spray treatment and the untreated controls. The three IPM strategies had similar effects, each significantly reducing the number of spiders but not eliminating them for about a month, but the pattern of reduction immediately after treatment was slightly different among the three strategies. Although we found live spiders in every brushed or vacuumed section at 2 wks and at every census afterwards, at 2 wks there were no spiders in 4 of the 8 sections treated with the Eco PCO EC-X spray. This suggests that the Eco PCO EC-X spray had a limited effect on the spiders. The effect of the Eco PCO EC-X essential oil spray was temporary, spiders reinvading all 8 sprayed sections by week 4. By 2 mos (15 August) there were about the same number of spiders present after brushing, vacuuming, or an essential oil spray as there had been in June when the treatments were made.

We recorded the approximate size of every spider we could find in each section at each census. A dramatic change in the average size of a treatment cohort within 2 to 4 wks suggests reinvasion or differential sensitivity of one stage of spider compared to another. Although we observed what appeared to be subtle differences in the size of the spiders in the treated cohorts, especially after using the Webster or the vacuum, the differences were not statistically significant ($P < 0.05$). The pretreatment mix of spider sizes did not statistically change 2 or 4 wks after any of the treatments, indicating that the treatments had about equal effects on large spiders and small ones.

Laboratory Direct Sprays. Cellar spiders are extremely sensitive to pyrethrins and permethrin sprayed directly onto them. As shown in Table 1, as little as 0.012% pyrethrins (1/16 LR_{max}) in the Eco PCO EC-X essential oil formulation killed 100% of sprayed *H. pluchei* in 30 min or less. That some spiders survived 4 hrs at the 0.006% rate suggests the 0.006% rate is probably near its lower limit of effectiveness. We did not evaluate the possible additive value of the rosemary. Table 2 shows that permethrin (Tengard) at 1/20 LR_{max} (0.025% permethrin) killed all sprayed *H. pluchei* within 4 hrs. This rate was also its minimum effective dose, 0.012% permethrin (1/40 LR_{max}) killing only 60% of sprayed spiders within 4 days. We also had good results with reduced rates of Temprid spray, a 1:2 combination of imidacloprid: beta-cyfluthrin. As little as 1/20 of the Temprid LR_{max} killed 100% of sprayed *H. pluchei* within 1 day. Since imidacloprid provided only mediocre kill of *H. pluchei* in preliminary trials, the good activity of 1/20

LR_{max} Temprid against cellar spiders was almost certainly attributable to as little as 0.005% beta-cyfluthrin, a pyrethroid insecticide. It is likely that lower than LR_{max} of beta-cyfluthrin (such as Tempo® SC Ultra) alone would be effective as a contact spray against cellar spiders. By comparison, the LR_{max} of Optigard Flex (thiamethoxam, 0.1%) killed only 20% of sprayed *H. pluchei* within 5 days and we did not test it at lower rates.

Discussion

Of the spider management methods we evaluated in the field against cellar spiders, only the LR_{max} Tengard permethrin spray eliminated all the spiders in every test section. In addition, it apparently provided a residual effect *vis-à-vis* its kill and repellency for at least 4 mos. The effect of each treatment is shown in Fig. 4. Brushing with a Webster, vacuuming, or spraying a LR_{max} essential oil containing a low rate of pyrethrins significantly reduced the number of spiders but did not completely eliminate them, even temporarily. Nonetheless, brushing or vacuuming cellar spiders and their cobwebs may be a wise management strategy because brushing and vacuuming removes cobwebs, which spray alone does not. If cellar spider webs are not removed first, spraying leaves a scraggly, matted, unsightly remnant silk mass that may be objectionable to homeowners. Spiders such as *H. pluchei* are semi-communal, tolerating nearby cellar spiders. They rearrange their webs frequently (Skow and Jacob, 2003) and generally take up residence under eaves of a building if a suitable website is available. If dislodged, they merely wander about until they find an abandoned web or within days they build a new web in a site suitable to them. Cellar spiders disperse by adults immigrating from a website or by young spiders merely walking away a few days after they hatch from an egg sac carried and cared for by their mother spider. Since they do not disperse by aerial ballooning on wind currents as do some of the more advanced spiders, it is unlikely that cellar spiders will reinvade over distance from surrounding areas following a thorough effective treatment.

There was no increase in the number of spiders in sections we brushed or vacuumed. We expected a possible invasion after we removed abandoned cobwebs. We were concerned that incoming spiders may fill the cleaned niches where spiders had previously built webs, resulting in more live spiders than before. That did not happen. This indicated that brushing or vacuuming, *per se,* does not provide a cleaned area into which spiders move and take up residence. We did not determine the effect of multiple

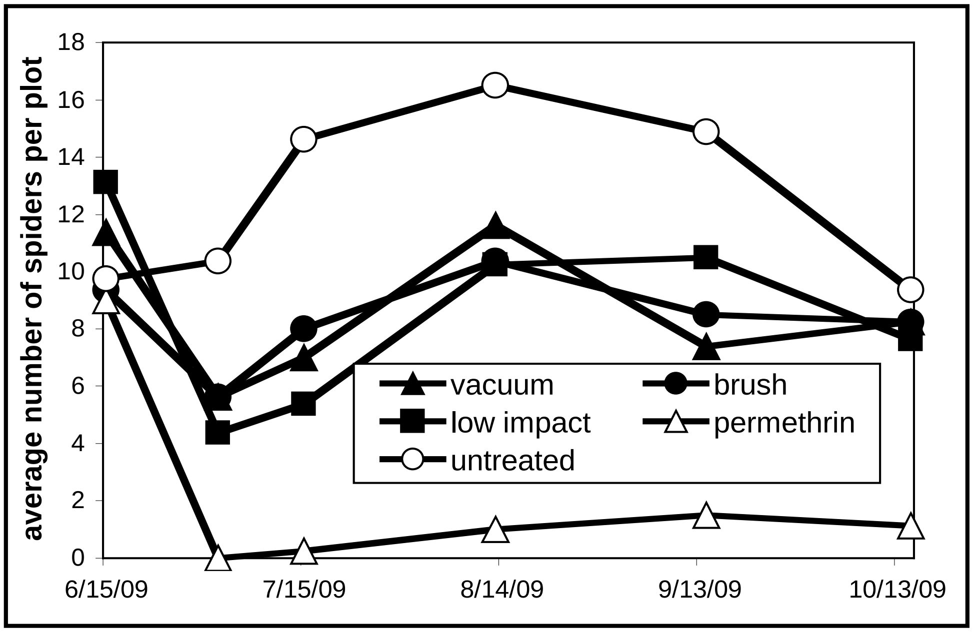

Fig. 4. The effect of one-time removal of cobwebs and cellar spiders, *Holocnemus pluchei*, with a Webster brush or vacuum vs. spraying 0.5% permethrin at maximum label rate. The pretreat spider census was made on 15 June 2009 and brushing, vacuuming and spraying were done 17-18 June 2009.

brushings, but it is likely that a few brushings or vacuuming spaced throughout the summer season would destroy reinvading adults and spiderlings and ultimately have more of an effect than just a single brushing or vacuuming. Brushing to destroy spiders and remove webbing followed by thorough spraying with a low rate of an effective low-impact spray is probably the best management practice for cellar spiders.

The *number* of live spiders per section after treatment depended on the effectiveness of the treatment, but their average *size* did not. A higher proportion of older (i.e. larger) spiders indicates that the treatment was more effective against the smaller immatures. Conversely, a higher proportion of small spiders indicates that the larger spiders have been killed or removed. That there was about the same proportion of small and large spiders throughout the study suggests that about equal numbers of adults or immatures were affected by any particular treatment. The sprays apparently affected both adults and immatures, and brushing and vacuuming were about as effective against the large spiders as the small ones.

Our laboratory spray trials showed that significantly lower rates of the sprays we used in this study as well as some other active ingredients in sprays may be effective against cellar spiders, especially if used in conjunction with cobweb removal and spider destruction. Label volume rates (1 gal per 750 ft^2) containing much lower than LR_{max} % of some low-impact toxicants are potentially highly effective against cellar spiders. For example, direct sprays of 0.025% permethrin (1/20 LR_{max}) or 0.012% pyrethrins (1/4 LR_{max}) killed 100% of *H. pluchei* within hours. Temprid was effective at the low rate of 0.005% (1/20 LR_{max} Temprid), low rates of it should be considered as an effective alternative. Similarly, we had good results in previous direct spray studies with low % rates of Cy-Kick CS (microencapsulated cyfluthrin) and Termidor SC (fipronil).

A single brushing or vacuuming reduced the number of spiders and cleaned out webbing. It is likely that brushing followed by spraying with a low rate of permethrin or pyrethrins would provide good IPM control of cellar spiders. Two or more brushings and low-rate sprays may be even more effective.

From a practical standpoint, the Webster brush was a more effective tool than was the vacuum. The collection canister of the Omega Vac Supreme is too small and the vacuum repeatedly clogged from a few leaves and debris. It is better suited for use indoors. A large-capacity, high-velocity dry shop vac may be a better for removing cellar spider cobwebs. The Webster, on the other hand, was easy to use, requires no electrical power, and has a flexible brush head that reaches into corners. The Webster brush head, however, looses its integrity within 1 to 2 hrs use, and needs to be replaced on a regular basis.

Summary

The cellar spider, *Holocnemus pluchei* (Scopoli) is a non-native species found in abundance in the southwestern United States. It is often the dominant species under the eaves and on the walls of homes. Requests for control of cellar spiders and are common for pest management professionals, sometimes representing >50% of summer service

calls. We tested four IPM strategies, sweeping and vacuuming, and two low-impact water-based sprays as control methods. The sprays included a botanical + pyrethrins and a permethrin emulsion. Treatments were made one time in June when there were large numbers of spiders present. Fifteen-foot sections of eaves on 13 separate buildings on the U.C. Riverside campus infested with *H. pluchei* were treated or left as untreated controls. Spiders per section were counted before treatment and at 2 wk and 1, 2, 3 and 4 mo after treatment. As expected, the number of spiders in the untreated sections gradually increased throughout the summer. They declined in fall. Permethrin, 0.5% (maximum label rate) nearly eliminated the spiders from every section for the duration of the study. Compared to the number of spiders in the untreated sections, the botanical spray, a single sweeping, or vacuuming had a measurable but marginal effect, reducing the number of spiders to a level approximately intermediate between the untreated sections and the permethrin spray treatment. Laboratory contact spray tests showed that <1/10 maximum label rates of pyrethrins, permethrin and other pyrethroids kill 100% of *H. pluchei* within a day. However, this high level of activity was only partially substantiated in the field. Webbing may shelter some spiders from direct spray and summer heat may reduce the effectiveness of low rates of spray. This study suggests that *H. pluchei* on homes may be controlled with single permethrin spray. Sweeping or vacuuming cobwebs coupled with treatment with a low rate of low-impact spray may also be effective. A single sweeping or vacuuming was not highly effective, but multiple sweepings that reduce webs and crush spiders may be.

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Statistix 9. Analytical Software. Tallahassee, FL.

Table 1. Mortality of marbled cellar spiders, *Holocnemus pluchei*, after being sprayed directly with aqueous dilutions of pyrethrins + rosemary (EcoPCO EC-X)[a].

Py rate (%)	Label rate	% Spiders dead at indicated time after being sprayed[b]						
		30 min	1 hr	4 hr	24 hr	48 hr	72 hr	96 hr
0.188	1	100						
0.09	1/2	100						
0.05	1/4	100						
0.02	1/8	100						
0.012	1/16	100						
0.006	1/32	0	0	100[c]				

[a] Concentrate contains 3% pyrethrins (Py); maximum label rate for spiders = 8 oz concentrate per gallon.

[b] For each % Py rate, individual intermediate-size spiders (n = 4) were sprayed with a hand-held trigger sprayer at rate of 1 gal per 750 ft^2 (1.3 gal per 1000 ft^2); Temp 78ºF; RH 37-41%. Tested October 2008.

[c] Lowest rate tested was 0.006% pyrethrins, above minimum effective rate (the % below which 100% kill is not attained within 72 hrs).

Table 2. Mortality of marbled cellar spiders, *Holocnemus pluchei*, after being sprayed directly with dilutions of permethrin emulsified concentrate (Tengard SFR).

Rate (%)	Label rate	% Spiders dead at indicated time after being sprayed[a]						
		30 min	1 hr	4 hr	24 hr	48 hr	72 hr	96 hr
0.5	1	100						
0.25	1/2	60	100					
0.05	1/10	40	100					
0.025	1/20	0	60	100[b]				
0.0125	1/40	0	0	60	60	60	60	60
0.0083	1/60	0	0	0	40	40	40	40
0.0625	1/80	0	0	0	0	0	0	0
0.0050	1/100	0	0	0	0	0	0	0

[a]For each % rate, individual intermediate-size spiders (n = 5) were sprayed with a hand-held trigger sprayer at rate of 1 gal per 750 ft^2 (1.3 gal per 1000 ft^2). Temp 78ºF; RH 41%

[b]Minimum effective rate, lower % rates not providing 100% kill within 72 hrs.