Bagrada Bug News

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Preparations Continue for Testing Parasitoids of Bagrada Bug at USDA-ARS in Albany, CA

By Brian Hogg and Keith Stokes

USDA-ARS, Exotic and Invasive Weeds Research Unit, Albany, CA

Classical biological control involves the introduction of natural enemies from an invader's native range to reduce populations of invasive pests to non-damaging levels. By establishing self-sustaining populations of natural enemies, biological control can be more cost-effective than other control methods, such as pesticides, which need to be continually reapplied. However, the candidate biocontrol agents must be thoroughly tested to ensure that they do not become pest species themselves. The possibility of detrimental effects of biological control is well known.

To demonstrate safety, candidate agents are exposed to species other than the pest species. Ideally, biocontrol agents are selected that have a high degree of specificity for the targeted pest species. The likelihood of non-target attack is typically determined by a combination of so-called choice and no-choice tests. In no-choice tests, the candidate is only offered either the pest or another species. In choice experiments, the candidate control agent is offered the opportunity to choose between attacking the pest species or another species.

The Hogg research laboratory at the USDA-ARS in Albany, CA, is maintaining laboratory cultures of bagrada bug and seven other stinkbug species for testing the

Natural enemies of crop pests must undergo rigorous assessment to ensure they don't become a pest themselves.

specificity of candidate control agents for bagrada bug, which will be conducted in coordination with Dr. Walker Jones at the USDA-ARS biological control laboratory in Stoneville, Mississippi, and Dr. Thomas Perring at UC Riverside. We recently received *Ooencyrtus* sp. and *Trissolcus* sp., and will soon receive *Gryon* sp., from Dr. Walker Jones. These are egg parasitoids (i.e., wasps that parasitize bagrada bug eggs). Parasitoids differ from parasites in that parasitoids typically kill their hosts relatively quickly, while parasites tend to kill their hosts

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Parasitoid Preparations
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slowly, or not at all.

We have also started sampling for natural enemies of bagrada bug that may already be in California, by placing cardstock with killed (previously frozen) bagrada bug eggs in cole crop fields in northern California. Two laboratory technicians, Alex Gutierrez and Erica Pollard, recently joined the Hogg lab to assist in these efforts.

Report from Abroad
Rearing Egg Parasitoids of Bagrada Bug

By Lincoln Smith, René Sforza, and Marie Roche

USDA-ARS European Biological Control Laboratory

Colonies of two hymenopteran parasitoids of bagrada bug originating from Pakistan are being reared at the European Biological Control Laboratory. The species have been tentatively identified as *Trissolcus hyalinipennis* and *Gryon* nr. *gonikopalense* by Elijah Talamas (USDA-ARS-Systematic Entomology Laboratory).

The parasitoid colonies are being maintained as iso-female lines at room temperature (ca. 24°C, 50% RH and 12 h photoperiod). Individual females are exposed to fresh bagrada bug eggs (0-24 h old) for at least 1 day for oviposition.

We have established three colonies of hosts, one containing a mixture of California "inland" and "desert" colonies from Tom Perring's laboratory, one from South Africa, and one from Pakistan. Data from colony maintenance indicates that host eggs from both California and South Africa are suitable for parasitism by both species of parasitoids. *Gryon* nr. *gonikopalense* parasitized 95% of California and 97% of S. Africa host eggs, and *T. hyalinipennis* parasitized 84% of California and 88% of South Africa host eggs.

The parasitoids are able to parasitize eggs collected from bagrada bugs in California and South Africa.

Survivorship to adult stage was also high for both species. *Gryon* nr. *gonikopalense* emerged from 92% of California and 98% of South Africa host eggs that were parasitized, and *T. hyalinipennis* emerged from 92% of California and 98% of South Africa host eggs.

These preliminary results indicate that both these species have the potential to attack bagrada bug from the USA, and thus warrant further study of their host specificity and potential to control bagrada bug under natural conditions.

Importance of Weeds for Bagrada Bug Populations in the Salinas Valley

By Ian Grettenberger,[1] Larry Godfrey,[1] Richard Smith,[2] and Shimat V. Joseph[2]

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A very similar version of this article was previously posted on the UC Weed Science blog Aug. 10, 2016.

Ed. Note: This field report contains specific scouting recommendations to growers, including:

- Shortpod mustard and perennial pepperweed are the two most important weeds for bagrada bug buildup in the Salinas Valley.
- Check weeds on the edges of fields and any large patches of weeds within 0.5 miles that may be likely sources of bagrada bugs.
- Bagrada bugs on weeds appear to be mainly a threat to crops once weed quality begins to decline, so observe the growth stage and overall condition of weeds.

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Progress on Funding for Biological Control of Bagrada Bug

By Charlie Pickett

California Department of Food and Agriculture

A Farm Bill "Suggestion" was submitted August 19 that would provide funding for one year of foreign exploration, host specificity testing, and survey work in California. The proposal is asking for $209,598 to be divided among four institutions: USDA Agricultural Research Service (ARS), University of California (UC) Riverside, California Dept. of Food and Agriculture (CDFA), and UC Cooperative Extension.

Funding will support host specificity work by USDA-ARS (Albany, CA) and UC Riverside, foreign exploration by USDA-ARS (European Biological

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Control Laboratory), and survey work in California for resident natural enemies by UC Cooperative Extension, USDA-ARS (Albany), and CDFA. We should hear back on whether or not the proposal is funded by March 2017.

With leftover funds from the USDA Animal and Plant Health Inspection Service 2015/2016 funding cycle, colonies of bagrada bug have been initiated and survey work has begun in California on the role of resident natural enemies in feeding on eggs of this pest. A similar proposal to above was submitted to CDFA's Specialty Crops Block Grant program last March. We will be notified around October 1 as to whether or not it is supported.

Figure 1. Adult and nymph bagrada bug on a still-green shortpod mustard plant after grasses have completely dried. Note the dead leaf tissue from bagrada bug feeding. All photos in this issue are by Ian Grettenberger.

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Bagrada bug (*Bagrada hilaris*) was first observed in the Salinas Valley in October-November 2013. We started monitoring bagrada bug populations in non-crop habitat up and down the Valley starting in 2015 and since then have continued to do so. We have seen bagrada bug developing on the weeds in spring and summer months. Weeds are clearly a key factor for bagrada bug populations in our region. While cruciferous crops are available year-round in the valley, stands of weeds are typically where populations really build up during early- and mid-summer (Fig. 1).

In the Salinas Valley, shortpod mustard (Figs. 2 and 3) and perennial pepperweed (Figs. 4 and 5) appear to be the two most important weeds for buildup of bagrada bug populations. We have found bugs (in extremely high numbers) on perennial wall rocket, but this was very late in the year when temperatures were cooling and after the time when bagrada bugs are typically problematic. These three weeds are non-native and invasive, just like the bagrada bug.

For our survey, we have been surveying a number of sites that cover the length of the Salinas Valley (Salinas, Chualar, Gonzales, Soledad, Greenfield, King City, San Lucas, San Ardo, and Watsonville). These sites contain a stand of at least one of these weed species, although we focused on pepperweed and/or shortpod mustard at the majority of the sites. Each month, we search for damage and bagrada bugs on the weeds at each site for 20 minutes or until insects are counted on five plants of each species. When leaves are actively growing and not already damaged and worn out, damage is often easier to detect than insects (Figs. 6 and 7). This is similar to scouting in fields, where checking plants for fresh damage is the recommended method of scouting (Palumbo 2015). Unfortunately, fresh damage can be hard to find on older weeds because old damage obscures fresh damage, leaves are

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extremely tough, and bugs feed on stems or seed pods. We therefore use damage to detect the (likely) presence of bagrada bugs and use counts of actual bugs to track populations.

When we surveyed near the end of June this year (2016), we did not find high populations of bagrada bugs or significant plant damage, although damage and/or insects were present at some sites. We were left wondering what would happen with bagrada bug populations this year. After our July and August sample dates, how 2016 populations compare with 2015 is still not clear, although we have now found enough bagrada bugs to suggest they may cause issues in at least some areas.

If anything, there may be a slight delay in bagrada bug movement into fields, although this is fairly speculative. The spring rainfall this year was greater than in 2015, although what effect rainfall had on winter and spring bagrada bug populations is not clear. In 2016, we added a number of new survey sites, so some sites have already been surveyed during one period of population peaks, while others have only been surveyed since the beginning of this year.

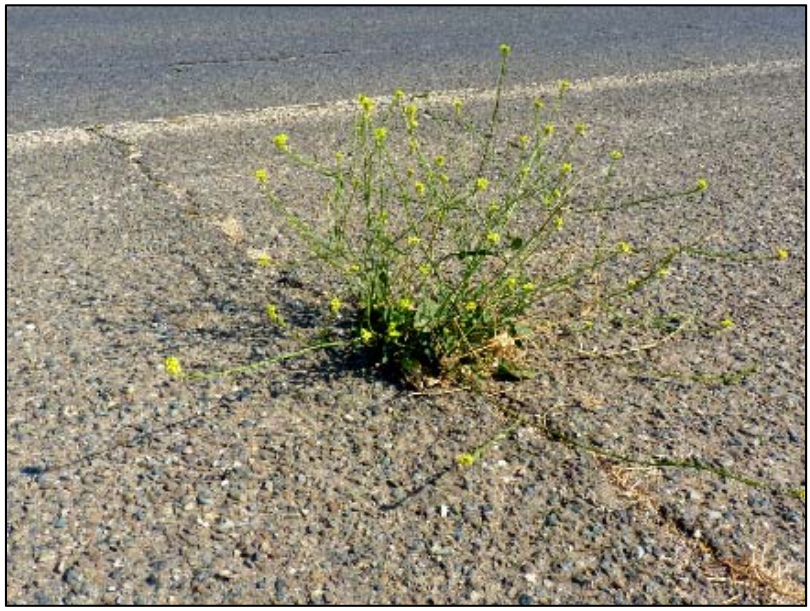

Figure 2. Shortpod mustard growing in the shoulder.

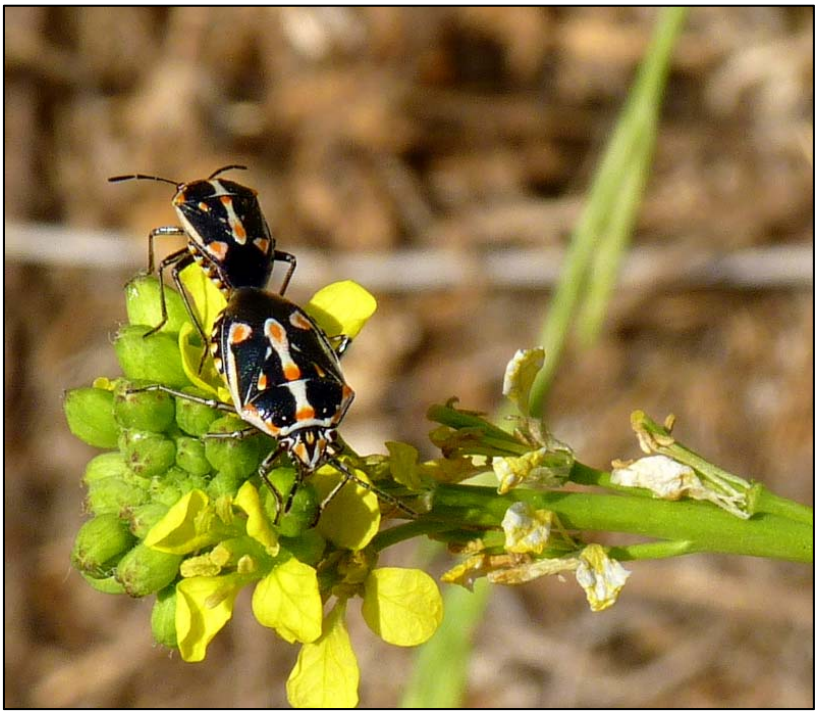

Figure 3. Bagrada bugs feeding on shortpod mustard flowers.

At the three sites we surveyed in 2015 with perennial pepperweed, we did not see populations jump until our survey time point in late August. This year, populations at one site are still very low. Last year, we found a large number of bugs at this site in August. Populations at another site have started to increase and were at 10 bugs per plant at the end of August. At some of the sites with shortpod mustard that we surveyed in 2015, we had already found a fair number of bagrada bugs by this time last year, including some large populations of nymphs (up to 3 to 5 adults per plant and 18 to 57 nymphs per plant). This year, we haven't seen the same populations yet at most of those sites. However, the same site that had 10 bugs per perennial pepperweed plant had populations on shortpod mustard averaging 25 adults and 15 nymphs

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per plant, clearly indicating bagrada bug populations at some sites are building.

Next, we have the sites that have only been surveyed in 2016. While the initial sites were chosen based on prior issues with bagrada bugs in nearby fields, the new sites were not necessarily chosen based on the same conditions. We chose these new sites to improve the coverage of our survey. Each site also contains at least one of the three weed species we have focused on (shortpod mustard, perennial pepperweed, or perennial wall rocket). A few sites were chosen knowing that bagrada bugs were present in 2015. A few of these sites have plenty of weeds available for bagrada bugs, but as of yet, we haven't seen any bugs. Some sites do have developing bagrada bug populations.

Figure 4. A stand of perennial pepperweed in the spring.

We found what appears to be growing populations of bagrada bugs on perennial pepperweed at one site near San Ardo on our last survey date (August 23). In the foothills near Gonzales, we found 1 to 26 bagrada adults and 0 to 22 nymphs on shortpod mustard plants. In addition, in July we were able to easily find bagrada bugs (0 to 8 adults, 0 to 3 nymphs) on shortpod mustard plants growing along US Hwy. 101 between Greenfield and King City (Fig. 8). Populations in this general area have since increased considerably and we have found a fair number of plants with > 50 adults or > 100 nymphs per plant. There are a lot of weeds in the roadside area on this stretch of road. This means that a handful of bagrada bugs on each plant can quickly add up to large populations when summed over thousands of plants. As the weeds senesce, bagrada bugs will likely concentrate on still-green plants, while continuing to reproduce, although this patch can only support the bagrada bugs for so long with plants continuing to senesce.

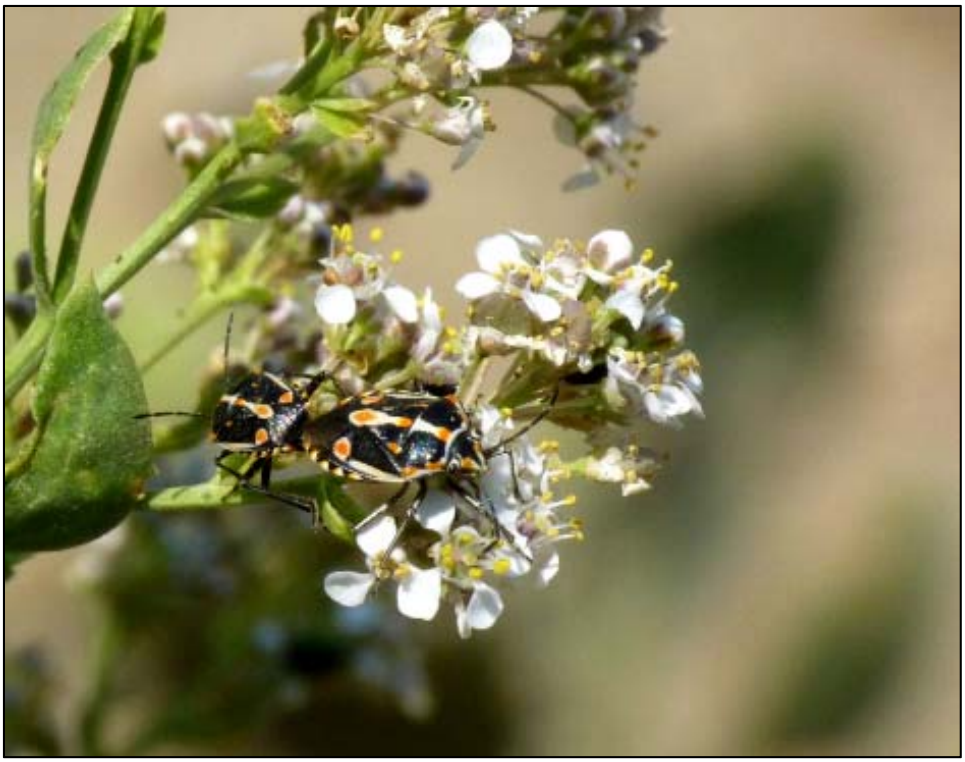

Figure 5. A pair of bagrada bugs on perennial pepperweed flowers.

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As we see it, the issue is when these growing populations of bagrada bugs run out of food in the patches of weeds and then go in search of new food sources. At this point, they can start finding their way into fields of cruciferous crops. This time of year, much of the shortpod mustard in the Valley is starting to set seed and will soon completely dry up if it has not already. In many locations, the vast majority of plants are almost dry. In the same area, some shortpod mustard plants will be completely senesced, while others are still green and flowering (see Figs. 9-13). Differences in growing conditions at a fairly small scale can therefore be very important. If all of the plants dry up, bagrada bugs will be forced to disperse, possibly triggering infestations in crop fields. If green plants remain, they may retain bagrada bugs, shifting the risk of infestation. Perennial pepperweed can persist late into the fall, but this is dependent on availability of water, damage by bagrada bugs, and disease pressure (pepperweed is often afflicted by white rust; Koike et al. 2011). The timing and severity of bagrada bug infestations in fields seems to be closely tied to what is happening on the weeds, so a better understanding of population dynamics on weeds will be needed to better predict an influx of bagrada bugs.

The next step will be to figure out how to incorporate bagrada

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Figure 6. Bagrada bug damage on perennial pepperweed. New lesions still appear green in color and with distinct lines or "fans" from the "lacerate and flush" feeding by bagrada bugs. Lesions turn white as they age and the leaf tissue becomes chlorotic.

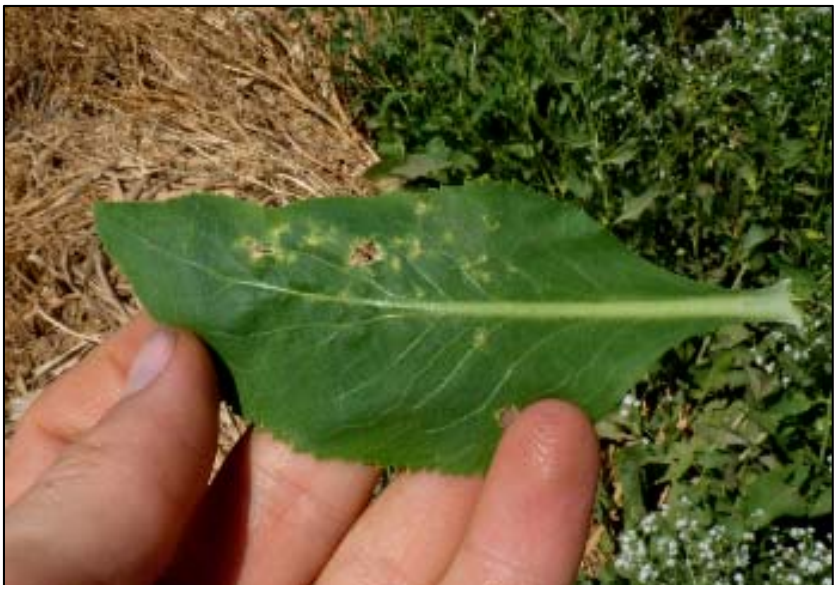

Figure 7. Older bagrada bug damage on pepperweed. Lesions have developed into tattered holes.

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bug populations in weeds into management and scouting plans. It is already common for pest control advisers (PCAs) to check weeds for bagrada bugs and we believe this to be a useful tactic. At this point, we suggest checking weeds on the edges of fields and any large patches of weeds within ~ 0.5 miles that seem to be likely sources of bagrada bugs. Consider which sides of crop fields often get infested the most and search for weeds on that side of the field. The dispersal ability of bagrada bugs has not been well characterized, but cases in which fields are colonized even when no cruciferous weeds or only bare ground is nearby show that bagrada bugs can move significant distances.

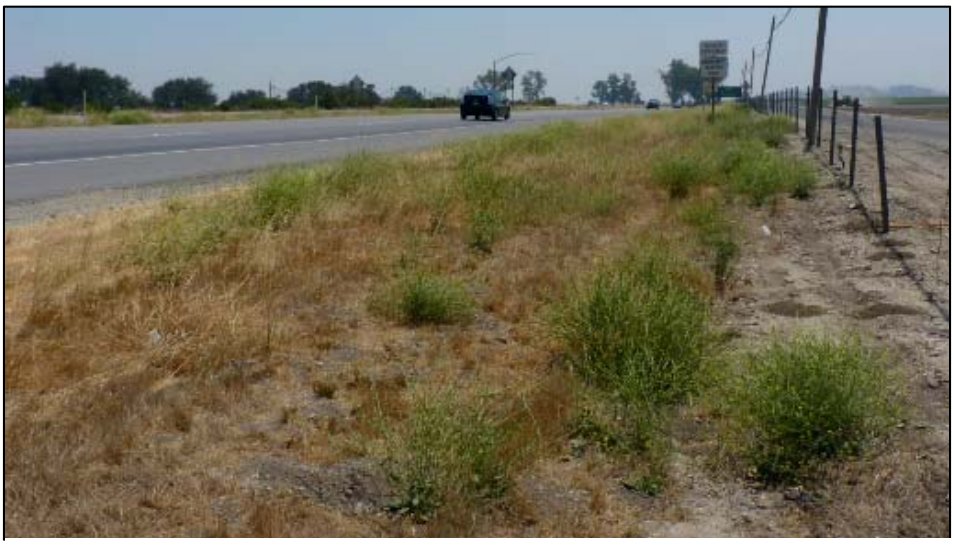

Figure 8. A typical roadside scene in the Salinas Valley (photo taken July 26). Some of the shortpod has completely senesced, but most plants still have green leaves, some flowers, and many pods.

While often seen walking, bagrada bugs readily fly, especially when temperatures are above 80°F (based on preliminary studies). When perennial pepperweed is green and leaves are growing, new or recent damage should be readily apparent. Damage on "old growth" shortpod mustard is not always readily apparent, so finding bagrada bugs themselves is necessary. Adults are often found feeding on flowers, buds, or seed pods, so these are the best plant structures to scan. We believe bagrada bugs on weeds are mainly a threat to crop fields once the quality of these plants starts to decline, so pay attention to weed phenology and damage severity on weeds from both bagrada bugs and disease.

Management of weeds is another option to limit the population growth potential of bagrada bugs. Sanitation of both weeds and crops has been a recommended cultural management tactic in the pest's Old World range (Palumbo et al. 2016). By removing nearby weeds, you may be able to prevent an economically significant infestation. If weeds are managed, the timing will be important. Even if nearby weeds didn't harbor bagrada bugs earlier in the season, they may serve as an intermediate bridge between the crop fields and weeds that are further away. Unfortunately, it is likely impossible to manage weeds far enough out from fields to eliminate the threat of bagrada bugs.

The landscape context is important, but exercising control over the entire landscape is not possible. For shortpod mustard, if it is possible to successfully manage weeds when they are still small, this may prevent buildup of bagrada populations from the very beginning. However, resurgence of the weeds may happen with sufficient soil moisture early in the year. A more efficient tactic may be to manage shortpod mustard once it has bolted and is flowering later in the season (~ late April to May). This will help prevent resurgence of weeds but will still intercept bagrada bug populations before they have a chance to build to a significant degree.

The timing of weed management could also be tied to the susceptibility of nearby crops, which could help if bagrada bugs are already present on the weeds. Adult bagrada bugs moving into a 40 day-old broccoli field because the weeds they were on were mowed or disked would likely not cause economic damage. However, managing weeds near a newly planted field could make matters worse and create a pest problem. Perennial pepperweed is a trickier weed to deal with given its phenology and ability to rapidly re-sprout.

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These weed species are not about to disappear from the landscape in the Salinas Valley, so they will continue to play an important role for developing bagrada bug populations.

See page 10 for literature citations.

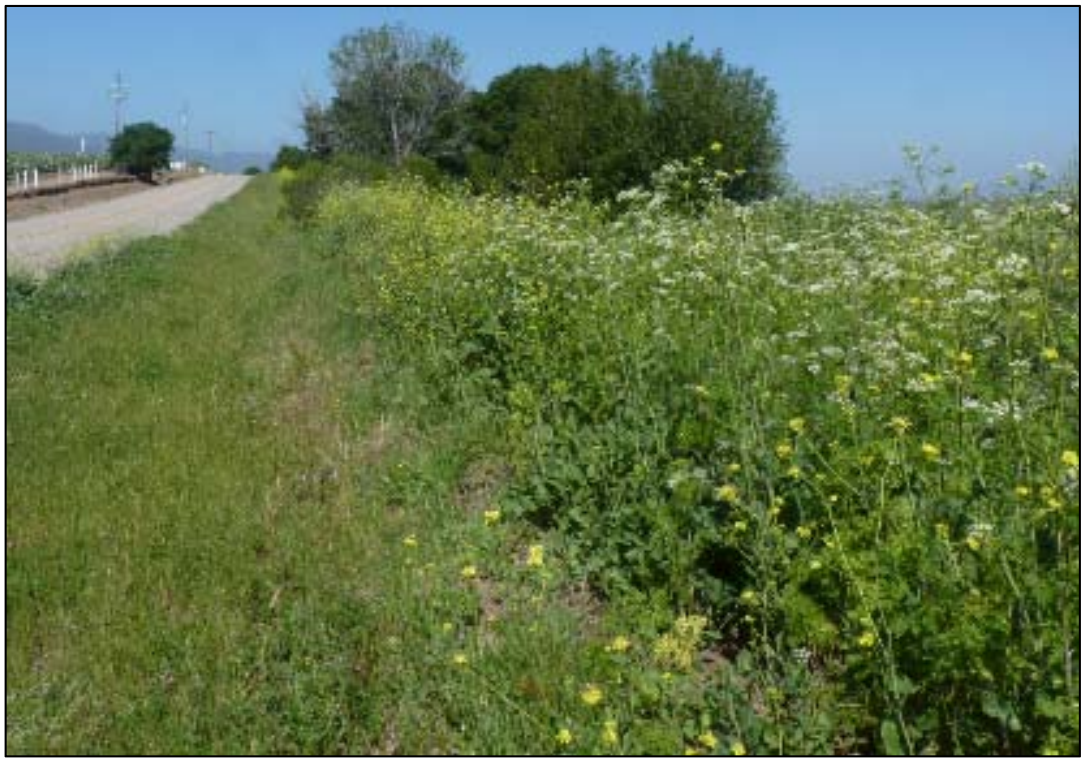

Figure 9. Shortpod mustard growing in the roadside near Gonzales, CA. Plants further from the road have almost completely senesced. Bagrada bugs were not found at this time point. Photo taken March 26, 2016.

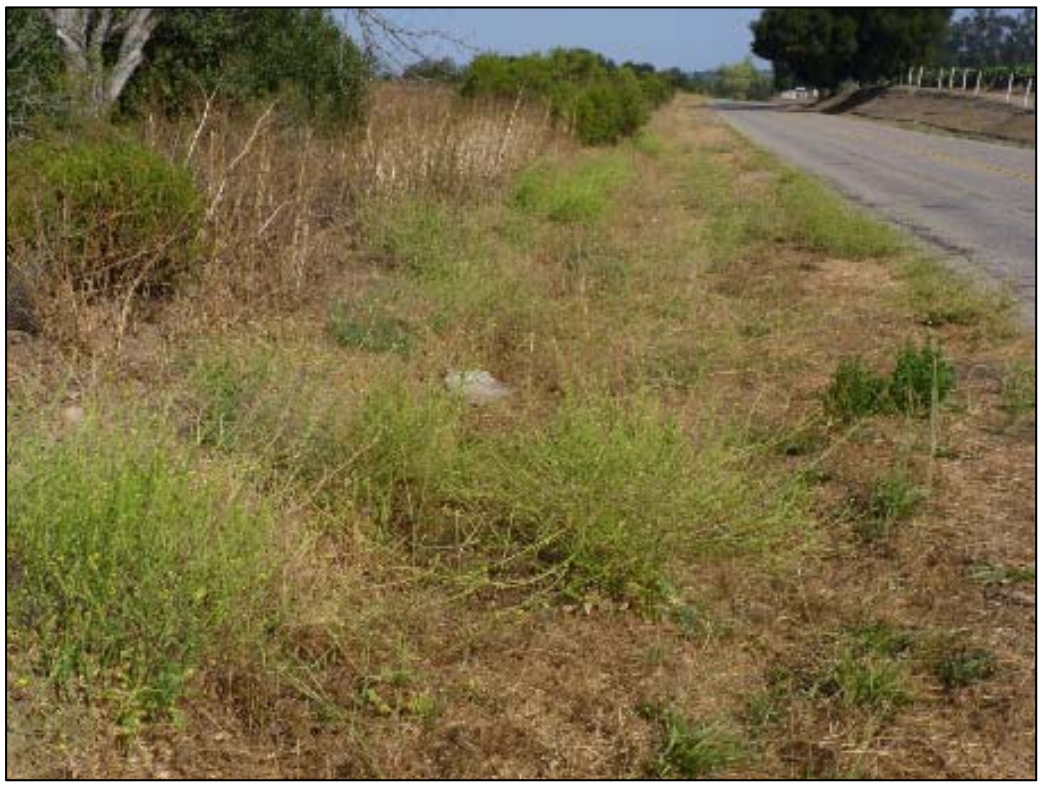

Figure 10. Shortpod mustard growing in the roadside near Gonzales, CA. Bagrada bugs were found on these plants. Photo taken July 26, 2016.

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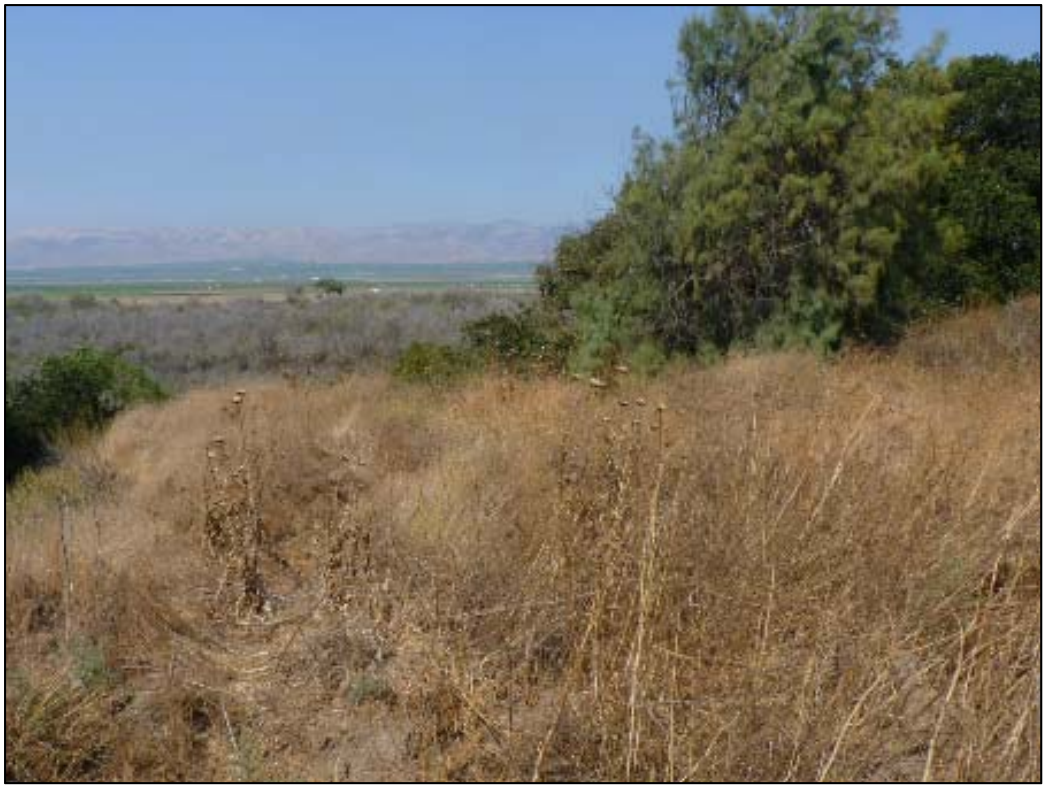

Figure 11. The same site near Gonzales, CA, further from the road. Plants are almost completely senesced. Bagrada bugs were found on these plants. Photo taken July 26, 2016.

Figure 12. Bagrada bugs feeding on the green pods on a shortpod mustard plant.

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Literature Cited

Koike, S. T., M. J. Sullivan, C. Southwick, C. Feng, and J. C. Correll. 2011. Characterization of white rust of perennial pepperweed caused by *Albugo candida* in California. Plant Disease 95:876.

Palumbo, J. C. 2015. Association between *Bagrada hilaris* density and feeding damage in broccoli--implications for pest management. Plant Health Progress 16:158–162.

Palumbo, J., T. Perring, J. Millar, and D. A. Reed. 2016. Biology, ecology, and management of an invasive stink bug, *Bagrada hilaris*, in North America. Annual Review of Entomology 61:453–473.

Figure 13. Bagrada bugs on a nearly completely senesced shortpod mustard plant.

About the Bagrada Bug News

Numerous agencies are cooperating in the effort to discover effective organic management and biocontrol of bagrada bug. Please refer any questions about this newsletter to editor Jane Sooby, jsooby@ccof.org. Design by Sarah Watters, CCOF.