

1. Title: Collecting, redistributing, monitoring populations and estimating impacts of the rush skeletonweed root moth, *Bradyrhoa gilveolella*

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2. Cooperators:

FHP Sponsor/Contact: Carl L. Jorgensen, Forest Entomologist; USDA Forest Service, Forest Health Protection-Boise Field Office, 1249 Vinnell Way, Suite 200, Boise, ID 83709; Tel: (208) 373-4225, Fax: (208) 373-4332, Email: cljorgensen@fs.fed.us

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Kim Goodwin, Dept. of Land Resources and Environmental Sciences, Montana State University, P.O. Box 173120, Bozeman, MT 59717-3120: Tel: (406) 994-5698

3. Amount Requested:

We are requesting \$67,157 over three years; with non-federal cost share of \$16,790, and federal in-kind of over \$309,000. If successful, this grant will be used to help leverage additional support from other sources.

5. Project Goal and Supporting Objectives:

The rush skeletonweed root moth, *Bradyrrhoa gilveolella*, has recently become establishment in North America. The only collectable population is located at one site in southern Idaho. This population is limited in its geographic distribution; therefore it is urgent that this biocontrol agent is quickly redistributed to new areas to avoid losing the establishment due to site disturbance, e.g. wildfire, spraying, etc. Before large scale redistribution efforts occur, collection and monitoring techniques need to be developed; and to justify this effort the potential effectiveness or impact of the moth needs to be assessed.

Project objectives are to:

- 1) Develop effective collection/adult monitoring techniques
- 2) Determine most efficient release methods & redistribute the moth to new sites
- 3) Determine the phenology, and spatial distribution of *Bradyrrhoa*
- 4) Develop methodologies for assessing impact of *Bradyrrhoa*

6. Project Justification/Urgency:

Rush skeletonweed (*Chondrilla juncea*) (RSW) (Asteraceae) is a widespread, invasive weed of Eurasian origin found through the semiarid areas of western United States. It is a long lived perennial with an extensive root system and, once established, outcompetes and replaces desirable forbs, grasses, and shrubs (Whitson et al. 1991, Holm et al. 1997). The worst RSW infestations are on private, National Forest, and BLM lands with reported infestations of over 6.2 million ac. (2.5 million ha) (Sheley et al. 1999). Infested land types include roadsides, railways, rangelands, pastures, grain fields, coastal sand dunes, and shaley hillsides in mountainous regions (Reed 1979; Sheley and Hudak 1995). Infestations of RSW continue to expand as much as 41,000 ha per year (Spollen and Piper 1995, Kinter et al. 2007), and this weed has recently spread to British Columbia and Montana. Because of the large area infested, high rate of dispersal, and difficulties in the use of herbicides (e.g., inaccessible infestations, variable susceptibility of populations to herbicides, low economic value), biological control is needed to economically combat RSW.

A biological control program was undertaken against RSW in the late 1970's that resulted in the successful introduction of three biological control agents: *Puccinia chondrillina* (rust), *Aceria chondrillae* (gall mite), and *Cystiphora schmidtii* (gall midge). While the three biological control agents have been established over most of the range of rush skeletonweed in California, Idaho, Oregon, and Washington; they have not provided effective control in many areas (Supkoff et al. 1988, Spollen and Piper 1995). As a result, additional efforts have been made to find, import, and establish a complex of new biological control agents capable of controlling rush skeletonweed. The root feeding moth, *Bradyrrhoa gilveolella* (Treitschke) (Lepidoptera: Pyralidae) was screened at the quarantine laboratory at Montana State University (Littlefield et al. 2000) and eventually released in Idaho starting in autumn of 2002. Past attempts to establish the moth in both Australia and Argentina have apparently failed (Julien and Griffiths

1998); but recently a sizeable population was observed in 2010 at a release site located in southern Idaho.

At one site located near Garden Valley, ID (~ 60 km NW of Boise) *Bradyrhoa* was detected at very low levels at the immediate point of release for approximately eight years after its initial release. Then in October 2010 we observed infested plants over a much larger area of ~ 7 ha. Although variable, percent infestation at the immediate point of release approached 70%. On average one larva was observed per root, although twice as many empty feeding tubes were observed. In early August 2011, adults were observed over a much wider area (~ 46 ha) although still confined to this one site. We estimated, based on adult counts, that the moth population exceeded 100,000 individuals. We are also currently monitoring the site for population increase and dispersal.

7. Approach:

Objective 1. Develop effective collection/adult monitoring techniques

Bradyrhoa adults are difficult to collect in large numbers using a sweep net and adults are not attracted to black light as other moths. To collect moths in adequate numbers for redistribution collection techniques need to be refined. This information will be supplemented by data collected under Objective 3.

- Compare different insect collecting techniques – we will compare the efficiency of various methods: sweep net, hand aspirating, vacuum, etc.
- Collecting at different times of the day – we will determine the optimum collection time for adults moths, e.g. morning, afternoon, evening.
- Determine collection efficiencies (catch per unit time) of the different collection techniques & times – we will identify optimal collection strategies.
- Investigate the use of pheromones as monitoring/ collection tools.

Objective 2. Determine most efficient release methods & redistribute the moth to new sites

We have a well-established population of *Bradyrhoa* at a single site. To reduce the risk of losing this population to an unforeseen event, e.g. fire, we will redistribute the moth to new locations and habitats.

- Release differing numbers – release varying numbers of moths to determine minimum number moths for establishment. We will utilize significantly greater numbers of moths (compared with previous releases) for releases.
- Cage vs. open-field release – we will determine if cages are more effective in containing & augmenting the initial release, or if cages interfere with the mating & oviposition behavior of the moth and therefore determine whether or not open-field releases are more effective.

- Monitor establishment – we will determine establishment of *Bradyrrhoa* by subsampling plants for infestation or by adult emergence within the plots/sites.

Objective 3. Determine the phenology, and spatial distribution of *Bradyrrhoa*

We will monitor the phenology of *Bradyrrhoa* to identify the duration of adult emergence. This will aid in collections and redistribution. We have also initiated a spatial distribution study to characterize the within-site population distribution of *Bradyrrhoa* adults and larvae in relation to host density.

- Twenty five plants will be periodically harvested to determine the development of larvae. Soil temperature will be recorded at this site.
- A sampling grid (11 x 11) with points located 20 m apart was established at the release site in spring of 2011.
- At each point plant density will be recorded both in the spring and autumn in permanent 0.25 m² quadrats.
- Five plants surrounding each point will be harvested also in the spring and autumn and dissected in the laboratory to determine the number of larvae per root, stage of larval development, and the diameter of the root.
- Adult counts will be made at each grid point through the emergence period. A five meter transect will be walked at each sampling point and the number of moths “kicked up” one or two meters on either side of these transects will be recorded.
- The within field spatial and temporal distribution of *Bradyrrhoa* relative to that of RSW density will be analyzed using SADIE analysis.

Objective 4. Develop methodologies for assessing impact of the moth

Methodologies to determine impacts associated with root feeding weed biological control agents are often lacking or inadequate. With this objective we hope to identify techniques that could be utilized to determine within site impacts associated with this root feeder. We suspect that any measureable, population-level impact of *Bradyrrhoa* on rush skeletonweed will take several years. Here, we plan to address techniques to quantify these impacts including how to manipulate presence/absence/abundance of the insect, and how to accurately measure plant performance.

- Cage vs. chemical exclusions
 - Cages as exclusions or inclusions using variable infestation levels of the moth (i.e. number of moths per unit area of RSW).
 - Determine effective insecticides and timing of treatment (selection of various insecticides rates & timing). Will utilize several classes of insecticides to determine their effect on *Bradyrrhoa* larvae.

- Impact on plant parameters and density – we will develop protocols to measure plant height, flowering, density, etc. to serve as base-line data to determine future impacts of the moth.

8. Expected Products & Outcomes:

Development of methodologies/technologies:

Project Objective 1:

- Produce a 1-2 page write up of the most efficient collecting method for *Bradyrrhoa*
- Have these write ups available on the ISDA Biological Control and FHP websites for land managers to access.

Project Objective 2:

- Produce a 1-2 page write up detailing release methods that have the best opportunity of population establishment; i.e. using cages or not, and how many moths to release.

Project Objective 3:

- Results will be submitted as a manuscript to a professional journal
- Off shoot of these data will be a 1-2 page tech transfer write up describing the most efficient monitoring methods for *Bradyrrhoa*.

Project Objective 4:

- Produce a manuscript describing the impacts that this insect may have on RSW at this site, and the methodology on how to measure those potential impacts.

All of these products would be presented at State weed meetings, as well as other professional meetings as either a poster or oral presentations. Manuscripts to professional journals, or a GTR, may be produced as a summary of the work. These are to be completed by winter 2014/2015.

Budget:

| Category | Total |
|---|------------------|
| Salaries: | |
| Technician: 3 mo. /yr. | \$ 25,605 |
| Summer student labor: 3 mo./yr. | \$ 5,000 |
| Benefits: | |
| Technician: ~39% | \$ 10,533 |
| Student: 10% | \$ 500 |
| Supplies: Cages, insecticides, bags, etc. | \$ 1,500 |
| Shipping Costs: FedEx | \$ 200 |
| Travel: Per diem, lodging, vehicle rental, gas | \$ 23,819 |
| IDC: MSU match 25% | - |
| Totals | \$ 67,157 |

Non-federal match includes: salary of Littlefield (\$8,395), and MSU IDC's not received (25% of project total = \$ 8,395) (Total \$16,790). Montana State University policy limits cost share matches to the level specified in the announcement. Federal in-kind match includes: Progar (\$8,000 salary & cages), Milan (\$8,000 salary, travel & cages), Runyon (\$8,000 salary & travel) and Jorgensen (\$ 6,900 salary & travel) (total \$309,000).

Timetable:

| | | | | | | | | | |
|-----------------------------------|----------------|----------------|-----------------|----------------|----------------|-----------------|----------------|-----------------|----------------|
| Objective 1 Collection | | | | | If Needed | | | | |
| Objective 1 Pheromone | | | | | | | | Field Tests | |
| Objective 2 Release | | | | | Monitor | | | Monitor | |
| Objective 3 Spatial | | | | | | | | | Cont. ?? |
| Objective 4 Impact | | | Monitor Only | | Monitor | Monitor Only | | Monitor Only | |
| | Spring 2012 | Summer 2012 | Autumn 2012 | Spring 2013 | Summer 2013 | Autumn 2013 | Spring 2014 | Summer 2014 | Autumn 2014 |

Shaded cells = peak activity; Not shaded cells = limited or no activity.

References:

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Julien, M. H., and M. W. Griffiths. 1998. Biological control of weeds: A world catalogue of agents and their target weeds. 4th ed. CABI Publishing. 223 pp.

Kinter, C.L., B.A. Meador, N.J. Shaw, and A.L. Hild. 2007. Postfire invasion potential of rush skeletonweed (*Chondrilla juncea*) . Rangeland Ecology and Management 60:386-394.

Littlefield, J.L., J. Birdsall, J. Helsley, and G. Markin. 2000. A petition for the introduction and field release of the Chondrilla root moth, *Bradysrrhoa gilveolella* (Treitschke), for the biological control of rush skeletonweed in North America. USDA-APHIS & Technical Advisory Group on the Biological Control of Weeds. 45 pp.

Perry, J.N., L. Winder, J.M. Holland, and R.D. Alston. 1999. Red-blue plots for detecting clusters in count data. Ecology Letters, 2, 106-113.

Reed, C. F. 1979. Skeletonweed in eastern United States. Phytologia 43: 201-217.

Sheley, R. L., and J. M. Hudak. 1995. Rush Skeletonweed: A Threat to Montana's Agriculture. Montana State Univ. Publ. EB-132, Bozeman, MT.

Sheley, R., J. Hudak, and R. Grubb. 1999. Rush skeletonweed. In R. Sheley and J. Petroff (eds.). Biology and management of noxious rangeland weeds. Oregon State Univ. Press.

Spollen, K. M. and G. L. Piper. 1995. Effectiveness of the gal mite *Eriophyes chondrillae*, as a biological control agent of rush skeletonweed (*Chondrilla juncea*) seedlings. pp. 375-379. In Delfosse, E. S. and R.R. Scott (eds). Proceed. Eighth Intern. Symp. Biol. Control of Weeds Symp. Canterbury, New Zealand 1992.

Supkoff, D. M., D. B. Joley, and J. J. Marois. 1988. Effect of introduced biological control organisms on the density of *Chondrilla juncea* in California. J. Appl. Ecol. 25:1089-1095.

Whitson, T. D., L. C. Burrill, S. A. Dewey, D. W. Cudney, B. E. Nelson, R. D. Lee, and R. Parker (eds). 1991. Weeds of the West. Western Society of Weed Science, Laramie, WY.

Curriculum Vitae of Principal Investigators:

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EDUCATION

Ph.D. 1986. Entomology. University of Wyoming, Laramie, WY
M.S., 1980. Entomology. University of Idaho, Moscow, ID
B.S.F. 1975. Forestry. University of New Hampshire, Durham, NH
B.S., 1975. Entomology. University of New Hampshire, Durham, NH

ACADEMIC APPOINTMENT

Research Scientist/Quarantine Director

MAJOR ADMINISTRATIVE RESPONSIBILITIES

My position has both a service and a research component. As Quarantine Director I am responsible for the maintenance and daily operation of the Biological Containment Facility for the importation of weed feeding organisms (arthropods and pathogens); maintaining permit, importation and release records and voucher specimens of imported organisms; "pass-through screening" of organisms (including screening for pathogens, parasites and confirming species identity); insect rearing, developing standard operating procedures and training personnel. In addition, I maintain the budget for the facility and seek grant support for its operation. In this position I develop risk assessment documents, both BAs and EAs, for field release of exotic organisms for biological control. I work closely with state and regulatory personnel for maintaining the certification of the containment lab and for the importation of various biological agents.

CURRENT RESEARCH

For research my primary emphasis is biological control of weeds, including the determination of host specificity, bionomics, and field release of potential biocontrol agents. In the past I have worked on insects attacking a variety of other weed species; as well as, parasitoids of the Russian wheat aphid, alfalfa weevil and the wheat stem sawfly. Currently I am investigating the use of gall mites (Eriophyidae) and other arthropods as potential biocontrol agents of field bindweed, Russian knapweed, invasive hawkweeds, and whitetop. I also have cooperative projects involving the biological control of hounds tongue, various forest weeds including tansy ragwort and rush skeletonweed. Through these projects I work with several co-investigators and cooperators from various state, federal and international agencies or organizations.

GRANT SUPPORT

Since 2008 I have had 29 grants funded and received approximately \$ 589 thousand in grant supported funding from a variety of sources, both federal and state, for the study, rearing and release of biological control agents for invasive hawkweeds; including hoary cress, tansy ragwort, field bindweed, Russian knapweed, rush skeletonweed, common tansy and ox-eye daisy. Funding supported overseas survey and screening of new biological control agents, and for domestic host testing, rearing, release and monitoring of these and other agents.

PUBLICATIONS, REPORTS & PRESENTATIONS

In the past three years I have authored or co-authored 13 reviewed or non-reviewed publications, conference proceedings, technical reports (including TAG petitions) and abstracts.

Justin Blake Runyon

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Education

Ph.D. Pennsylvania State University, Entomology, May 2008.
M.S. Montana State University, Entomology, May 2001.
B.S. University of Virginia's College at Wise, Biology and Mathematics, 1998.

Professional Employment

2008-present Research Entomologist, USDA Forest Service, Rocky Mountain Research Station
2008-present Adjunct Faculty, Dept. of Plant Sciences & Plant Pathology, Montana State University
2001-2003 Research Associate, Department of Entomology, Montana State University

Selected Publications

- Birdsall, J. B., W. McCaughey, and J. B. Runyon. 2011. Roads impact the distribution of noxious weeds more than restoration treatments in a lodgepole pine forest in Montana, USA. *Restoration Ecology*, DOI: 10.1111/j.1526-100X.2011.00781.x
- Runyon, J. B., M. C. Mescher, G. W. Felton, and C. M. De Moraes. 2010. Parasitism by *Cuscuta pentagona* sequentially induces JA and SA defence pathways in tomato. *Plant, Cell and Environment* 33: 290-303.
- Runyon, J. B., M. C. Mescher, and C. M. De Moraes. 2010. Plant defenses against parasitic plants show similarities to those induced by herbivores and pathogens. *Plant Signaling and Behavior* 5: 929-931.
- Runyon, J. B., J. F. Tooker, M. C. Mescher, and C. M. De Moraes. 2009. Parasitic plants in agriculture: chemical ecology of germination and host location as targets for sustainable control: a review, pp. 123-136. In E. Lichtfouse (ed.) *Organic Farming, Pest Control and Remediation of Soil Pollutants*, Sustainable Agriculture Reviews 1.
- Weaver, D. K., M. Buteler, M. L. Hofland, J. B. Runyon, C. Nansen, L. E. Talbert, P. Lamb, and G. R. Carlson. 2009. Cultivar preferences of ovipositing wheat stem sawflies as influenced by the amount of volatile attractant. *Journal of Economic Entomology* 102: 1009-1017.
- Piesik, D., D. K. Weaver, J. B. Runyon, M. Buteler, G. E. Peck, and W. L. Morrill. 2008. Behavioral responses of wheat stem sawflies to wheat volatiles. *Agricultural and Forest Entomology* 10: 245-253.
- Runyon, J. B., M. C. Mescher, and C. M. De Moraes. 2008. Parasitism by *Cuscuta pentagona* attenuates host plant defenses against insect herbivores. *Plant Physiology* 146: 987-995.
- Runyon, J. B., M. C. Mescher, and C. M. De Moraes. 2006. Volatile chemical cues guide host location and host selection by parasitic plants. *Science* 313: 1964-1967.
- Mescher, M. C., J. B. Runyon, and C. M. De Moraes. 2006. Plant host finding by parasitic plants: a new perspective on plant to plant communication. *Plant Signaling and Behavior* 1: 284-286.

Joseph D. Milan

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Education

B.S. in Biology, College of Idaho, Caldwell, Idaho. (3.3/4.0 GPA) 146 credits completed (semester hours). June 2, 2001.

M.S. in Entomology, University of Idaho, Moscow, Idaho. (3.7/4.0 GPA) 40 credits completed (semester hours). December 19, 2005. Thesis titled: "Control efficacy of the biological control agents *Eriophyes chondrillae* and *Puccinia chondrillina* on rush skeletonweed, *Chondrilla juncea*, L."

Professional Experience

Bureau of Land Management (BLM)/Idaho State Department of Agriculture (ISDA), Natural Resource Specialist – Biological Control

Boise District Office, Division of Operations, Boise, Idaho, Jan. 2006 - present

Duties include developing and implementing a monitoring protocol to assess the overall fitness and effectiveness of recent and past biological control releases within Idaho and BLM nationwide, providing on-site biological control expertise with regard to future direction, reasons why past releases may have failed, and additional agents that should be implemented (if applicable) to Field Offices (FO) within the state, utilizing GIS software (ArcMap) to identify trends contributing to the successful establishment of biological control agents, compiling a list of FO biological control needs from points of contact at each FO and creating a timeline for addressing those needs, conducting national training through the BLM National Training Center regarding biological control and on-site training for established monitoring protocols at each FO within Idaho, providing biological control practitioners with initial release and monitoring forms (both paper and electronic) in order to gain an accurate understanding of biological control agent release status, assuring that biological control activities are reported as field office units of accomplishment statewide, providing technical biological control assistance to BLM and county weed superintendents to include organizing biological control collection trips, workshop presentations, assisting in identifying ideal release sites for those agents, and correctly recording essential release site data, coordinating with regional biological control specialists to identify potential insectaries for biological agents not currently available for collection within the state, publishing information pertinent to the continued advancement of biological control, serving as a technical reviewer of biological control bulletins, publications, and peer-reviewed journals, providing biological control comments and insights pertinent to the International Code of Best Practices on FO Environmental Assessments, representing Idaho BLM at National Weed Team Meetings, and drafting and adhering to Idaho BLM and Idaho State Department of Agriculture's Strategic Plan for Biological Control of Noxious and Invasive Weeds.

ROBERT PROGAR

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EDUCATION

- Ph.D.** West Virginia University, Morgantown, WV 26506.
M.B.A. Frostburg State University, Frostburg, MD 21532.
M.S. West Virginia University, Morgantown, WV 26506.
B.S. West Virginia University, Morgantown, WV 26506.
A.A. Potomac State College, Keyser, WV 26726.
B.S. West Virginia University, Morgantown, WV 26505.

Additional Academic Study

- Survival of trees after fire injury.
Use of semiochemicals to manage bark beetles.
Biocontrol of introduced invasive weeds.

Professional Experience

- 2008-present Research Entomologist, PNW Research Station, LaGrande, OR
2003-2008 Research Entomologist, PNW Research Station, Corvallis, OR
2000-2003 USDAFS, Forest Health Protection Entomologist
1996-2000 Postdoctoral Research Associate Oregon State University

Recent publications in invasive plant biological control:

- Progar, R.A., G. Markin, J. Milan, T. Barbouletos and M.J. Rinella. 2011. Short-term population dynamics and impacts of the red-headed leafy spurge stem borer (*Oberea erythrocephala* (Schrank.) Coleoptera: Cerambycidae) on leafy spurge (*Euphorbia esula*). *Invasive plant science and management*. 4:183-188.
- Progar, R. A., G. Markin, J. B. Milan, T., and M. J. Rinella. 2010. Inundative release of *Aphthona* spp. flea beetles (Coleoptera: Chrysomelidae) as a biological "herbicide" on leafy spurge (*Euphorbia esula* L.) in riparian areas. *J. Economical Entomology*. 103:242-248.