Potential for Biological Control of Perennial Pepperweed (*Lepidium latifolium* L.)

J.L. Birdsall, P.C. Quimby, Jr., T.J. Svejcar, and J.A. Young

INTRODUCTION

Perennial pepperweed (*Lepidium latifolium* L.) in the Brassicaceae family ("crucifers") is a herbaceous perennial weed that reproduces by seed and stoloniferous rhizomes. This species is native to southern Europe and western Asia, but now inhabits Mexico, Canada, and many parts of the United States including the Atlantic Coast and all of the far western states except Arizona (Whitson et al. 1992, Young et al. 1995). Perennial pepperweed readily spreads along river systems where plants infest riparian and wetland areas (Young et al. 1995). This weed also establishes in waste places, ditches, irrigated land, roadsides, croplands, and fields.

Several features of perennial pepperweed make this species very difficult to control with conventional measures. Mechanical control of perennial pepperweed is limited as new plants easily sprout from root buds contained on small sections of the creeping roots (Young et al. 1995). Grazing is inhibited as a control measure because of the persistence of semi-woody stems. Before grazing can be used in the early spring to suppress this weed, the old stems must first be reduced by mowing, brush beating, or burning. Grazing may also be impractical as a control measure if perennial pepperweed proves to be poisonous to livestock. Most cases of suspected poisoning occurred under confined conditions where horses were fed hay containing perennial pepperweed (Young et al. 1995).

Perennial pepperweed may be similar to whitetop [*Cardaria draba* (L.) Desv.] in plant response to herbicides. Whitetop is difficult to control chemically due to the short period of maximum carbon allocation to below ground tissue, the large proportion of below ground tissue, and the wide variation in phenology among plants at any given time (Miller et al. 1994). While phenoxy herbicides easily kill the tops of perennial pepperweed, the root and crown buds rapidly sprout and require repeated treatments (Young et al. 1995). The sulfonylurea herbicides have shown some promise for control. Dupont recommends controlling perennial pepperweed with 0.75 oz of Escort® (metsulfuron) or 1 oz of Telar® (chlorsulfuron). While Escort® has no grazing restrictions at rates up to 1.67 oz/acre, Telar® is not registered for range or pasture lands. Both Escort® and Telar® are terrestrial herbicides. In situations where perennial pepperweed infests waterways, the applicability of these herbicides may be limited (Cantlon 1995, Young et al. 1995). Additional factors hamper the usefulness of herbicides for controlling perennial pepperweed. The persistent semi-woody stems of perennial pepperweed interfere with chemical application (Young et al. 1995). Perennial pepperweed often infests remote, inaccessible areas of low economic value where chemical control is neither practical nor cost-effective. In addition, herbicides can kill competing vegetation, including natives and threatened, endangered, and sensitive species. The subsequent lack of competition might allow perennial pepperweed or another weed to readily reestablish.

Because perennial pepperweed has been difficult to control with conventional measures, interest is increasing for developing a biological control program for perennial pepperweed. This paper will address the potential for such a program.

Biological Control

To date, no biological control programs have been established to control a cruciferous plant, although the Brassicaceae family contains about 350 genera and 3,000 species, several of which are serious weeds. The lack of biological control programs may stem from the number of important cultivated and ornamental plants in this family such as canola, mustard, cabbage, and kale, which are now cosmopolitan because of agricultural activities (Lipa 1974). However, as the crops are generally annuals and perennial pepperweed is a perennial, suitable biological control agents might be identified that attack only the persistent vegetative structures of the weed. This strategy might confer some protection to the annual crops. Additional protection would be conferred if biological control agents could be found that were specific to perennial pepperweed or to the genus *Lepidium*.

The genus *Lepidium* is one of the largest genera of the Brassicaceae (Mummenhoff 1994). Worldwide there are between 130 to 175 species (Lipa 1974, Young et al. 1995). Over 20 *Lepidium* species are present in western North America (Britton and Brown 1970). However, none of the native or introduced species found in western North America are very similar in size and growth habit to perennial pepperweed, (Young et al. 1995) which may help in the search for host specific biological control agents. In anticipation of the environmental assessment process required for approval of biological control agents, we examined the threatened, endangered, and sensitive species within the *Lepidium* genus in the United States and Canada. There is one federally endangered *Lepidium* species in the United States, one additional species proposed for federal listing, nine additional species the U.S. Fish and Wildlife service is concerned about, one additional species listed by the U.S. Forest Service as sensitive, three additional species listed by a state natural heritage program, and one additional species listed in Canada (Table 1).

Classical biological control has traditionally involved using exotic insects as control agents, although exotic plant pathogens have been used in some cases (Quimby and Birdsall 1995). Perennial pepperweed is widely distributed in southern Europe and western Asia. There are numerous countries that can be explored for potential classical biological control agents including Austria, Albania, Armenia, Belgium, Bulgaria, Czechoslovakia, Denmark, Finland, France, Germany, Great Britain, Greece, Holland, Hungary, India and Himalayas, Iran, Ireland, Italy, Kurdistan, Lebanon, Norway, Poland, Portugal, Romania, Russia, Spain, Sweden, Switzerland, Tibet, Turkey, and Yugoslavia (Bobrov et al. 1970, Holm et al. 1979). A study has already been undertaken to explore the insect fauna on cruciferous plants in Poland (Lipa 1974). Several general feeding insect species were reported on perennial pepperweed and eight other *Lepidium* species including *L. campestre*, *L. densiflorum*, *L. graminifolium*, *L. neglectum*, *L. perfoliatum*, *L. ruderale*, *L. sativum*, and *L. virginicum*. While no insects specific to perennial pepperweed were found, the potential for finding host specific species has not been exhausted.

Augmentative biological control using plant pathogens might also be possible with perennial pepperweed. Augmentative biological control involves manipulating natural enemies that are already present in a location and has traditionally involved the use of fungal plant pathogens that are often applied in somewhat the same manner as chemical herbicides (Quimby and Birdsall 1995). Several species of fungi have been identified that might be appropriate for augmentative biological control of perennial pepperweed. Jim Young noted a white rust occurring on many of the perennial pepperweed plants in the Honey Lake Valley area in Nevada during the 1995 summer season. The rust is believed to be *Albugo candida* (Pers.) Kuntze, which has been reported from other *Lepidium* and crucifer species (Farr et al. 1989). Under apparently ideal conditions, the rust was able to prevent seed production but did not kill the plants. Over 20 other fungi, including *Sclerotinia sclerotiorum*, have been reported on *Lepidium* species in the United States (Farr et al. 1989). In addition, the fungi *Alternaria alternata* and *Albugo lepidii* have been reported on *L. sativum* (Melkania 1980, Rao 1979). *Alternaria alternata* and *Sclerotinia sclerotiorum* have been investigated as potential biological control agents of other weedy species (Miller et al. 1989, Stierle et al. 1988).

Often, achieving successful management of troublesome weeds requires integrated management that includes biological controls as well as chemical and other techniques. When some fungal plant pathogens have been used in conjunction with certain chemical herbicides, insecticides, fungicides, or plant growth regulators, positive effects have occurred that increase pathogen effectiveness. These positive effects include weakened host defenses, improved colonization by the pathogen, and reduced rates of chemicals required for weed control (Quimby and Birdsall 1995). To successfully control perennial pepperweed, opportunities should be investigated for combining augmented fungi and/or bacteria with low doses of herbicides registered for riparian zones.

The U.S. Department of Agriculture - Agricultural Research Service (USDA-ARS) is considering developing a biological control program for perennial pepperweed and two other cruciferous weeds: dyers woad (*Isatis tinctoria* L.) and whitetop or heart-podded hoary cress [*Cardaria draba* (L.) Desv. = *Lepidium draba*]. At present, we recommend that biological control efforts begin with development of a host specificity test plant list for Brassicaceae targets, and with foreign exploration and quarantine work aimed at identifying potential biological control agents for perennial pepperweed, whitetop, and dyers woad. An evaluation of the economic and environmental losses caused by these weeds might also be beneficial in generating support for a control program.

CONCLUSION

At present, prevention is the best policy for managing perennial pepperweed. Transporting equipment and hay from infested areas is apparently a major means of new introduction. Equipment should be thoroughly cleaned before transport. Hay and seed sources should be checked to ensure that there is no perennial pepperweed contamination. New infestations should be controlled promptly to prevent further spread. However, because prevention is not always possible and perennial pepperweed is a serious weed threat, this species deserves to be examined as a target for biological control, particularly since conventional control measures have been largely unsuccessful or impractical. Both the classical and augmentative biological control approaches have potential for controlling this weed and warrant further examination. The existence of closely related threatened, endangered, and sensitive species and related crop and ornamental species will pose challenges for a biological control program, but do not necessarily negate biological control as an option to be included in integrated management systems. As with other weeds, successful control of perennial pepperweed will undoubtably require an integrated management system where biological controls are used in conjunction with other available techniques.

Table 1. Threatened, endangered, and sensitive *Lepidium* species in the United States and Canada[1].

1994 Federal Threatened and Endangered List

1. *Lepidium barnebyanum*, Barneby ridgecress = peppercress, UT, Endangered[2]

1996 Federal List of Plant Species Under Review for Listing

1. *Lepidium arbuscula*, Anaunau, HI, Proposed as Endangered

1993 Federal List of Plant Species Under Review for Listing[3]

1. *Lepidium arbuscula*, Anaunau, HI, Category 2[4]
2. *Lepidium bidentatum* var. *remyi*, Remy's Anaunau, HI, Category 2 but possibly extirpated in wild
3. *Lepidium davisii*, Davis' peppergrass, ID & OR, Category 2
4. *Lepidium flavum* var. *felipense*, Borrego Valley peppergrass, CA, Category 2
5. *Lepidium jaredii* ssp. *album*, Panoche peppergrass, CA, Category 2
6. *Lepidium jaredii* ssp. *jaredii*, Jared's peppergrass, CA, Category 2
7. *Lepidium montanum* var. *papilliferum*, ID, Category 2
8. *Lepidium montanum* var. *stellae*, kodachrome peppergrass, UT, Already proposed to be listed as endangered
9. *Lepidium ostleri*, UT, Category 2
10. *Lepidium serra*, Anaunau, HI, Category 2

Forest Service Sensitive Plant Lists

Region 4:

1. *Lepidium montanum* var. *neeseae*, Neeses' peppergrass, Dixie Natl. Forest, Sensitive
2. *Lepidium papilliferum*, Slick-spot peppergrass, Caribou Natl. Forest, Sensitive

State Natural Heritage Program Lists

California:

1. *Lepidium flavum* var. *felipense*, Borrego Valley peppergrass
2. *Lepidium jaredii* ssp. *album*, Panoche peppergrass

3. *Lepidium jaredii* ssp. jaredii, Jared's peppergrass
4. *Lepidium latipes* var. *heckardii*, Heckard's peppergrass
5. *Lepidium virginicum* var. *robinsonii*, Robinson's peppergrass

Hawaii:

1. *Lepidium arbuscula*, Anaunau
2. *Lepidium bidentatum*
3. *Lepidium bidentatum* var. *o-waihiense*, Anaunau
4. *Lepidium bidentatum* var. *remyi*, Remy's Anaunau
5. *Lepidium serra*, Anaunau

Idaho:

1. *Lepidium davisii*, Davis' peppergrass

Nevada:

1. *Lepidium montanum* var. *nevadense*, Pueblo Valley peppergrass

Oregon:

1. *Lepidium davisii*, Davis' peppergrass, List 1: Threatened with extinction or presumed extinct throughout range.

Utah:

1. *Lepidium barnebyanum*, Barneby ridgecress = peppercress, Endangered
2. *Lepidium ostleri*, Federal Category 2

Washington:

1. *Lepidium oxycarpum*, Sharp-fruited peppergrass, Sensitive

Wyoming:

1. *Lepidium montanum* var. *alyssoides*, List 2: Moderately rare globally, regionally, or in WY

Canadian Lists

British Columbia:

1. *Lepidium densiflorum* var. *pubicarpum*, Red List: Candidates for endangered or threatened status, extirpated taxa, and globally rare taxa
2. *Lepidium virginicum*, Yellow list: May become vulnerable in near future

---

[1] Forest Service regions, U.S. states, and Canadian provinces not appearing in the table had no listed *Lepidium* species.

[2] When available, information is provided on scientific name, common name, historic range, and listing status.

[3] In 1996, the U.S. Fish and Wildlife Service completed an exhaustive review of the 1993 candidate species to ensure that they truly warranted issuance of a proposed listing and to reevaluate the relative listing priority of each species. Listing of Category 2 species was discontinued because sufficient information to justify issuance of a proposed rule was lacking. While the Fish and Wildlife Service does not regard Category 2 species as candidates for listing and no longer lists these taxa, the Service remains concerned about these species and acknowledges the need for further biological and field study of these species.

[4] In 1993, Category 2 taxa were described as taxa for which information in the possession of the U.S. Fish and Wildlife Service indicates that proposing to list as endangered or threatened is

possibly appropriate, but for which sufficient data on biological vulnerability and threat are not currently available to support proposed rules. The Service hoped that the notice would encourage necessary research on vulnerability, taxonomy, and/or threats for these taxa.

LITERATURE CITED

Bobrov, E.G., N.A. Bush, E.G. Chernyakovskaya, B.A. Fedchenko, N.V. Pavlov, E.N. Sinskaya, A.I. Tolmachev, I.T. Vasil'chenko, and A.V. Yarmolenko. 1970. Flora of the USSR: Volume VIII. Israel Program for Scientific Translations, Ltd., Jerusalem, 524 pp.

Britton, N. Lord and Hon. A. Brown. 1970. An Illustrated Flora of the Northern United States and Canada in Three Volumes: Volume I. Dover Pubs., Inc., New York, NY, 735 pp.

Cantlon, J.D. 1995. Selective Vegetation Control. Dupont Agricultural Products, Wilmington, DE, 18 pp.

Farr, D.F., G.F. Bills, G.P. Chamuris, and A.Y. Rossman. 1989. Fungi on Plants and Plant Products in the United States. APS Press, St. Paul, MN, 1252 pp.

Holm, L., J.V. Pancho, J.P. Herberger, and D.L. Plucknett. 1979. A Geographical Atlas of World Weeds. John Wiley & Sons, Inc., New York, NY, 391 pp.

Lipa, J.J. 1974. Survey and Study of Insects Associated with Cruciferous Plants in Poland and Surrounding Countries: Final Report, November 1, 1969 to October 31, 1974. Inst. of Plant Prot., Lab. of Biol. Contr., Miczurina 20, Poznan, Poland, 310 pp.

Melkania, N.P. 1980. *Lepidium sativum*, Linn. - A new host record for *Alternaria alternata* (Fr.) Keissler. Current Sci. Bangalore 49:27-28.

Miller, R.F., T.J. Svejcar, J.A. Rose, and M.L. McInnis. 1994. Plant development, water relations, and carbon allocation of heart-podded hoary cress. Agron. J. 86:487-491.

Miller, V., E.J. Ford, N.J. Zidack, and D.C. Sands. 1989. A pyrimidine auxotroph of *Sclerotinia sclerotiorum* for use in biological weed control. J. Gen. Microbiol. 135:2085-2091.

Mummenhoff, K. 1994. Subunit polypeptide composition of RUBISCO as a taxonomic tool in separating critical *Lepidium* species. Phytochem. 35:683-684.

Quimby, P.C., Jr. and J.L. Birdsall. 1995. Fungal agents for biological control of weeds: Classical and augmentative approaches. Pp. 293-308 in Novel Approaches to Integrated Pest Management, Reuven Reuveni (Ed.), Lewis Publishers, Boca Raton, FL, 369 pp.

Rao, A.N.S. 1979. New species of white rust and sooty mold fungi, *Albugo lepidii*, on leaves of *Lepidium sativum* (garden cress). Indian J. Mycol. Plant Pathol. 9:283.

Stierle, A.C., J.H. Cardellina II, and G.A. Strobel. 1988. Maculosin, a host-specific phytotoxin for spotted knapweed from *Alternaria alternata*. Proc. Natl. Acad. Sci. 85:8008-8011.

Whitson, T.D., L.C. Burrill, S.A. Dewey, D.W. Cudney, B.E. Nelson, R.D. Lee, and R. Parker. 1992. Weeds of the West. Western Soc. Weed Sci., Newark, CA, 630 pp.

Young, J.A., C.E. Turner, and L.F. James. 1995. Perennial pepperweed. Rangelands 17:121-123.