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Biological control of knapweed and spurge: Principles and status[1]

JIM STORY

Jim Story is an entomologist with the Western Agricultural Research Center in Corvallis, Montana, where he initiated a program for biological control of knapweed in 1976. His current research also includes sulfur cinquefoil and hounds tongue.

The conventional methods of weed control, namely chemical, cultural and mechanical, are not providing adequate solutions to the problem of weeds on rangeland in Montana and other areas of the Pacific Northwest. This is evidenced by the steady increase in weed-infested acreage. In Montana alone, spotted knapweed, first reported in the state in 1927, now infests an estimated four million acres of rangeland. Leafy spurge, first reported in the state in 1923, now occupies an estimated 550,000 acres.

A major reason for the rapid spread of these weeds is that the plants are introduced species and therefore lack the complex of natural enemies that effectively regulate their densities in their native eastern Europe. In view of this, Montana State University, in cooperation with USDA-ARS, and USDA-APHIS, has established a program which seeks to fill these natural enemy voids with Eurasian-collected organisms proven to be host-specific to the respective target weeds. This approach, known as biological control, is rapidly gaining public support.

Nearly all of the noxious rangeland weeds in Montana and the Pacific Northwest are exotics, most being indigenous to Eurasia. For the most part, these plants are insignificant and often scarce in their native areas. Because these exotics were introduced without their natural enemies, they are able to easily out-compete the native plants and become "weedy." Although some of the success of these weeds in North America could be due to genetic changes, there is no question that most of the invasiveness of these plants is due to the natural enemy void. The importance of natural enemies coupled with the obvious limitations of conventional control methods have resulted in increasing interest in "biological" weed control.

Classical biological weed control (biocontrol) is the deliberate use of natural enemies, i.e., insects, mites, nematodes, or pathogens, to reduce weed densities to tolerable levels. Of these, insects have been the most widely used against weeds because of their great variety, high degree of host specialization and specific adaptations to their host.

Biological control is attractive because it is permanent, selective, energy self-sufficient, comparatively economical and environmentally safe because no toxic substances are introduced into the environment. However, biological control is not without its limitations. It is a slow process, does not achieve eradication, is often too selective, and cannot be used against weeds that are valued under some situations because insects don't recognize boundaries. Biocontrol methods cannot be used against weeds that are closely related to beneficial plants because the insect may be unable to discriminate among the related plant species. Finally, the use of insects against cropland weeds under intensive cropping practices is not feasible due to the continual elimination of the host weed.

One fear about biocontrol is that newly introduced insect species will attack beneficial plants. To protect against such mistakes, all prospective biocontrol agents are tested to insure that they will not attack non-target plants that are of economic or ecological importance.

The testing process is essentially a starvation test. Each insect species is tested on a large number of test plants, often more than 100 species. If the insect feeds or develops on any important test plants, it is dropped from further consideration. But if, after repeated trials, the insect refuses to feed or develop on any of the many test plants and starves to death, it is considered safe for introduction.

The entire testing process takes three to four years. The test results are bolstered by knowledge that the close relationships between the host-specific insects and their host plants have evolved over millions of years and thus, there is very little chance that these insects would abandon this relationship for another plant in just a few years. The biocontrol approach, in use for over a century, has an excellent safety record. No introduced agent has ever become a pest of a non-target plant species unexpectedly.

Biocontrol of spotted knapweed

The statewide biocontrol of spotted knapweed research effort is being conducted at the MSU/Western Agricultural Research Center near Corvallis, Mont. A dozen insect species have been introduced into Montana for biological control of spotted knapweed (Table 1). Two seed head gall flies (*Urophora affinis* and *U. quadrifasciata)* are well-established throughout the state; a seed head moth *(Metzneria paucipunctella),* a root moth *(Agapeta zoegana),* and a root weevil *(Cyphocleonus achates)* are established in moderate numbers at several sites; a root moth *(Pelochrista medullana),* two seed head flies *(Terellia virens* and *Chaetorellia acrolophi),* and two seed head weevils *(Larinus minutus* and *Larinus obtusus)* have been recovered in small numbers; while a root moth *(Pterolonche inspersa)* and a seed head weevil *(Bangasternus fausti)* have not been recovered

We have recently begun collecting data on the impact of those insect species that are established. We have determined that the two gall flies are reducing spotted knapweed seed production by at least 50 percent in areas where the flies coexist. Even greater seed reduction has been documented where the two gall flies and the moth, *Metzneria paucipunctella,* coexist. Recently, we have documented measurable reductions in knapweed biomass and density due to the root moth, *Agapeta zoegana,* and the root weevil, *Cyphocleonus achates,* at study sites.

The two aforementioned insects, *A. zoegana* and *C. achates,* are the most promising agents to date. However, both of these insects have very slow reproductive rates and disperse slowly (especially *C. achates* which doesn't fly). To hasten establishment of these two insects throughout the knapweed infested areas of the state, we have initiated a mass rearing effort. We are currently rearing about 30,000 *A. zoegana* and 11,000 *C. achates* per year for subsequent release in other areas of the state.

Table 1.

Insects Released Against Spotted Knapweed in Montana

Species	Type	Degree Established
Urophora affinis	Seed head fly	Well
Urophora quadnfasciata	Seed head fly	Well
Mefznena paucipunctella	Seed head moth	Low numbers
Agapetazoegana	Root moth	Moderate numbers
Cyphocleonus achates	Root weevil	Moderate numbers
Pelochrista medullana	Root moth	Possible
Pteroionche inspersa	Root moth	Not yet
Larinus obtusus	Seed head weevil	Low numbers
Larinus mibutus	Seed head weevil	Low numbers
Terellia virens	Seed head fly	Low numbers
Chaetorellia acrolophi	Seed head fly	Low numbers
Bangastemus fausti	Seed head weevil	Low numbers

Biocontrol of leafy spurge

Leafy spurge is causing great concern because severe infestations are located throughout the state. This deep-rooted perennial plant is competitive, persistent, and extremely difficult to control with herbicides. The plant reproduces both by seed and rhizomatous roots.

The biocontrol research on leafy spurge is being conducted primarily by the USDA/ARS. Ten insect species (eight root insects, one seed head insect, and one defoliator) have been introduced against leafy spurge. Of these, four insect species are well-established, two species are established in moderate numbers at several sites, three species are established in small numbers, and one species was just recently introduced. Of the insects introduced, the most exciting are the four root-feeding flea beetles (*Aphthona* spp.). Reductions in spurge density due to the flea beetles have recently been documented. Although similar in action, each flea beetle species has different site requirements (i.e., moist versus dry; shady versus sunny, etc.). Each of the four species is established at one or more sites in Montana.

Biological control is definitely going to play a major role in the ultimate management of exotic weeds. Unfortunately, the increasing restrictions and costs associated with the use of chemical herbicides and cultural practices may result in greater demands on and expectations of biocontrol than are justified. As noted earlier, biocontrol is not a "cure-all" and, therefore, cannot be looked upon as the sole solution to rangeland weed control. Successful management of our exotic rangeland weeds will be a long-term effort involving the combined use of biological, chemical and other control methods, other cultural practice, and improved land management practices in an integrated approach.