

The outlook for biological control

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Biological control is seldom attempted against weeds on cultivated lands, because herbicides generally provide economical, efficient control, and farming practices may interfere with the biological agents. Field bindweed, however, reproduces from seeds that may remain alive in the soil for more than 40 years and from an extensive perennial root system. Control by cultivation or chemicals is difficult, at best. A search for biological control agents therefore seemed warranted. Even if such agents were effective only on field bindweed growing along roadsides and in other uncultivated areas, they would reduce the weed's potential for further invasion of cultivated land. A cooperative U.S. Department of Agriculture and University of California project was begun in 1970 to find biological agents for control of field bindweed.

Between then and 1979, Rosenthal and a co-worker, Gary Buckingham, collected arthropods and diseases that attack field bindweed and its close relatives in its native habitat, the Mediterranean area and Middle East. Trips were made to Italy, Greece, the Iberian Peninsula, Turkey, and Iran and to several other European countries. At each location, plants were inspected for damage, and arthropods were collected with an aspirator, hand-picked, or swept from the plants with a net. Seeds and whole crowns were collected, from which organisms were later reared or dissected.

The foreign work also included preliminary biological and host specificity studies of the most promising biological control agents, using: bouquets of test plant material in ½-pint (0.2-liter) cardboard cartons; whole, small plants grown in peat pellets or small pots; outdoor plants in field cages; and randomly planted test species in an experimental garden in Greece. We conducted some final host specificity screening using test plant bouquets in cardboard cartons in the U.S. Department of Agriculture quarantine laboratory in Albany, California. Since 1980, Rosenthal has also collected natural enemies of field bindweed and the closely related wild morning glories in the genus *Calystegia* in California. By comparing the kinds of natural enemies associated with field bindweed and its close relatives in the Mediterranean and in Cali-

fornia, we have found a pattern that may be used to help select the most suitable European organisms for biological control.

Our discussion focuses on such species and excludes many insects attracted to the flowers for pollen or nectar as well as many crop pests for which field bindweed is an alternate host. For example, we did not include the spider mites *Tetranychus cinnabarinus* Boisduval and *T. urticae* Koch, which are very common and damage field bindweed leaves in late summer. Various sucking insects in the families Aphididae, Cercopidae, and Pentatomidae feed on field bindweed leaves, stems, and seed capsules, respectively, but they also feed on nearby crop plants. Natural enemies that could damage commercially valuable plants, primarily sweet potato, *Ipomoea batatas* (L.) Lam., or ecologically valuable plants such as native *Calystegia* spp. cannot be introduced into the state. While hedge bindweed, *Calystegia sepium* (L.) R. Brown, is a serious pest in the eastern United States, the native California morning glories in this genus are not considered troublesome. Two of them are rare plants that are under review for protection as endangered or threatened species.

European plant feeders

Foliage feeders. About 80 percent of the natural enemies of field bindweed in the Mediterranean are associated with the foliage. Some of these, particularly *Bedellia somnulentella* Zeller (Lepidoptera: Lyonetiidae), are internal leaf miners. Externally feeding plume moth caterpillars (Pterophoridae), primarily *Emmelina (Oidaematophorus) monodactyla* (L.) and leaf beetles (Chrysomelidae), are most commonly seen on foliage in the early half of the growing season; other lepidopterous defoliators become more abundant later in the year. The most widespread moth of this latter group is *Tyta luctuosa* (Denis & Schiffermueller) (Noctuidae). Gall mites (Eriophyidae) distort and gall the leaves and buds. The most common foliar disease is powdery mildew caused by the fungus *Erysiphe convolvuli* DC.

Flower and seed feeders. Some 17 percent of the Mediterranean natural enemies of bindweed feed on the flow-

ers, seeds, or seed capsules. The most destructive organisms are the seed beetles (Bruchidae), especially *Spermophagus sericeus* (Geoffroy). In Greece, smut caused by the fungus *Thecophora seminis-convolvuli* (Desmaz.) Lioro infects up to 17 percent of the seeds.

Stem and root feeders. The remaining Mediterranean natural enemies attack the stems and roots. The agromyzid fly, *Melanagromyza albocilia* Hendel, is the most widespread stem borer. The pyralid moth, *Noctuella floralis* (Huebner), attacks stems and roots externally. The most common root feeder is the larva of the flea beetle, *Longitarsus pellucidus* Foudras (or very near). The adult feeds on the leaves.

California plant feeders

Foliage feeders. As might be expected, field bindweed has fewer natural enemies in California that it has in its place of origin. The natural enemies of the native North American morning glories, however, are more numerous and tend to specialize in much the same way as species associated with bindweed and morning glories around the Mediterranean. The previously mentioned leaf miner and plume moth are distributed worldwide and already occur in California on both field bindweed and *Calystegia* spp. They have been considered as possible biological control agents for field bindweed and hedge bindweed in the eastern United States, but both feed readily on sweet potato and native morning glories. Therefore, they cannot be used in California, and their spread or augmentation anywhere in North America would seem unwise.

A chrysomelid leaf miner, *Brachycoryna delbrosa*, can be numerous in the leaves of woolly morning glory, *Calystegia malacophylla* (Greene) Munz, but it appears unable to live in the thinner leaves of field bindweed. Lepidopterans that feed on a variety of plants, such as the omnivorous leaf tier, *Cnephasia longana* (Haworth), attack field bindweed in California, but no host-specific or specialized Lepidoptera have been associated with the weed as they are in Europe. Tortoise beetles (Cassidinae) are commonly found on native morning glories but are seldom seen attacking field bindweed. A gall mite, *Eriophyes* sp., forms leaf galls on *Calystegia fulcrata* (Gray) Brummitt but is not found on field bindweed.

Leaf spotting has occasionally been seen on field bindweed, but no fungus has yet been isolated from such spots. Rust caused by the fungus *Puccinia convolvuli* (Pers.) Cast. is seen on leaves of six *Calystegia* spp. but not on field bindweed, even though it is considered to be a host of this fungus.

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Range improvement, cont'd

the annuity. If the yield increase cannot be quantified, this will be a subjective evaluation.

The possible sale of firewood, now a profitable product for many ranchers, will affect the method of improving wooded ranges. After the wood is harvested, the area can be seeded for improved range capacity. The Hopland Field Station has had a one-time yield of 12¼ cords per acre with a conservative stumpage price of \$5 per cord. Although the money from selling firewood may finance the seeding costs, the firewood and seeding should be evaluated separately for profitability. Costs of seeding after firewood harvest convert to an equivalent annuity of \$1.09 per acre (table 2), which should be compared with expected benefits and variations as described.

Field Bindweed, cont'd

Flower and seed feeders. The bruchid beetle *Megacerus impiger* Horn frequently attacks seeds of all the California *Calystegia* spp. but only rarely is found in field bindweed seeds. The smut found in Greece also occurs in northern North America but is not found in California.

Stem and root feeders. No California organisms are associated with field bindweed stems, but the cecidomyid fly, *Lasioptera convolvuli* Felt, forms stem galls on western morning glory, *Calystegia occidentalis* (Gray) Brummitt. The sweet potato flea beetle, *Chaetocnema confinis* Crotch, like its European counterpart, *Longitarsus pellucidus*, feeds on roots in its larval stage and on leaves in its adult stage. It attacks both field bindweed and the native morning glories.

In spite of field bindweed's extensive system of roots and rhizomes, few organisms attack the underground portions of the plant in the Mediterranean, North America, or other areas where it has been studied. Organisms associated with other parts of the plant, however, occur in Europe and would be worth investigating as biological control agents where gaps in the fauna exist in California: late-season, specialized Lepidoptera; leaf beetles, gall mites, and fungus diseases of the leaves; seed-destroying organisms; and stem feeders.

In preliminary tests conducted in Europe on a variety of plant species in the Convolvulaceae and other plant families, the moth *Tyta luctuosa*, the leaf beetle *Galeruca rufa*, and seed beetle *Spermophagus sericeus* appeared to feed only on *Convolvulus* and *Calystegia* spp.

The advantage of the equivalent annuity approach is the ease of adjusting the benefits to evaluate potential values of conversion, production, and livestock prices. Estimation of the net present value of these improvements and the subsequent sensitivity should give the same answer. The annuity method is suggested only in those instances where the yields and prices are not known and estimates of the benefits are very uncertain. In these cases subjective evaluation will be assisted by the relatively easy, equivalent annuity method.

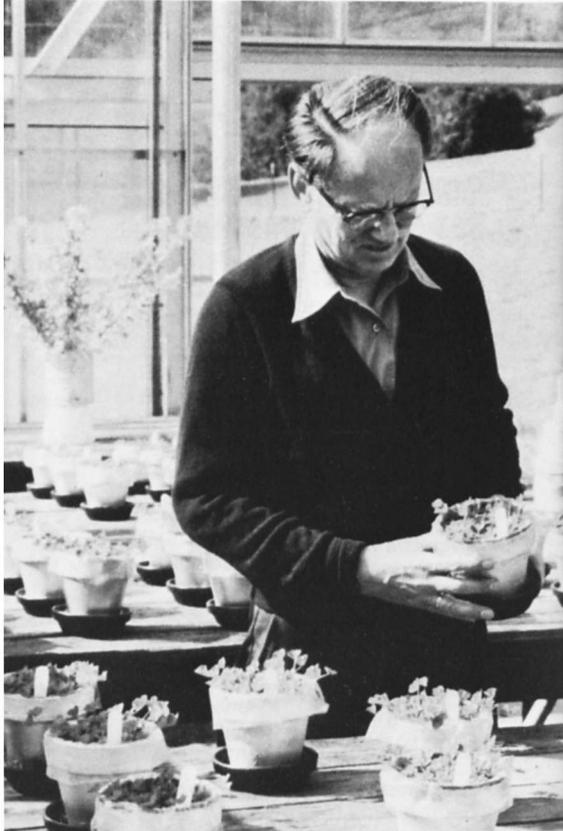
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Further tests conducted with the leaf beetle in the quarantine facility at Albany, however, indicated that this beetle could feed and reproduce on several North American sweet potato varieties.

The gall mite *Aceria convolvuli* Nalepa, from Greece, which attacks field bindweed buds and leaves, did not feed on American sweet potato varieties in laboratory tests, but tests on American morning glories are not complete. The powdery mildew appears to attack *Convolvulus* and *Calystegia* spp. Neither natural enemy has been thoroughly studied yet, but both organisms, or at least some closely related organisms, offer promise of being specific.

In conclusion, because some American sweet potato varieties and native North American morning glories (*Calystegia* spp.) are susceptible to attack by organisms associated with field bindweed, it will not be easy to find adequately host-specific biological control agents that may be used against this weed in California or any other area of North America.

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