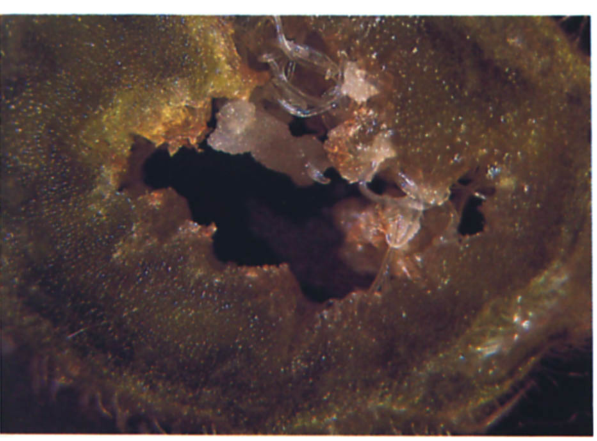
Biological control of fiddleneck

Dan James Pantone □ Stephen M. Brown □ Christopher Womersley

Costly to control chemically, this poisonous weed may be vulnerable to an assortment of natural enemies

Fiddleneck can take over a crop, as it has in the small-grain field in San Luis Obispo County at top. The fiddleneck gall nematode, which induces the weed to form floral galls that replace the flowers (above), is a potential control agent. A dehydrated, coiled nematode in a dried gall (below) can survive three years or more, and be revived in 30 minutes.



Fiddleneck is a winter annual, native California weed common in alfalfa, wheat, oats, barley, orchards, and rangelands. Fiddleneck is toxic to livestock, sometimes causing death. Pyrrolizidine alkaloids are present to varying degrees in the different species of fiddleneck (*Amsinckia*) and commonly cause irreversible liver damage in cattle, hogs, and horses. In some California counties, growers have been unable to sell alfalfa because of contamination with fiddleneck; hay from small grains is also frequently contaminated, and the incidence of livestock poisonings due to fiddleneck may be higher than realized.

Although effective herbicides are available for use in small grains, fiddleneck is particularly difficult to control in alfalfa because few of the registered chemicals can control postemergent infestations. Moreover, the relatively low value of alfalfa per acre may not justify the expense of developing new chemicals for fiddleneck control. Our studies are aimed at controlling the weed with the help of some of its natural enemies: the fiddleneck gall nematode, a gall midge, and pathogenic fungi.

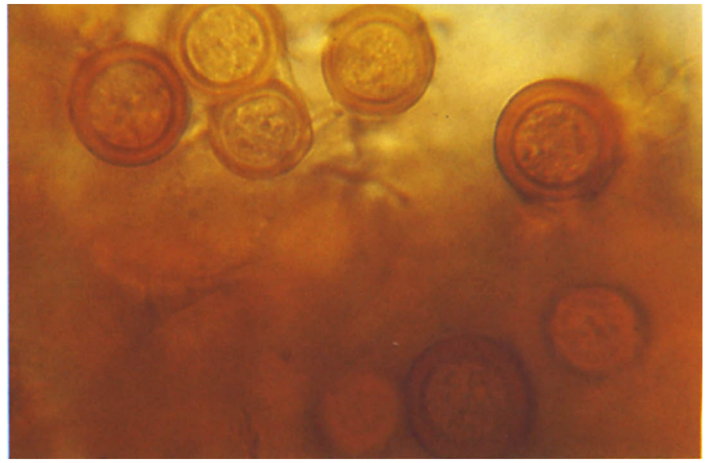
Beneficial nematode

The fiddleneck gall nematode (*Anguina amsinckia*), also native to California, induces the weed to form floral galls that replace the flowers. Although the mechanism is somewhat of a mystery, feeding by *Anguina* in the flowers apparently stimulates the floral tissues to form a gall that encloses the nematode. Two complete life cycles take place within the flower galls, and about 40,000 nematodes occur in an average ⅜-inch-diameter gall.

During the late spring and summer, the nematodes fall to the ground in dried galls, where they remain until revived by autumn and winter rains. Fiddleneck seedlings are attacked by the nematodes from fall to early spring.

The nematode may be suited for use as a biological control agent, because it can survive drought, high temperatures, and the absence of a host by undergoing anhydrobiosis — a resistant, dehydrated state in which no metabolism occurs. Three characteristics typify this gall-forming nematode in this state: the body coils; individuals clump tightly together; and individuals partially embed in the wall of the

The gall midge feeds on fiddleneck but itself may be prey for other natural enemies, which limit its numbers.



Leaf smut, one of four fungi that attack fiddleneck, causes disease in the weed by infecting the leaves.

gall. Since the fiddleneck nematode can survive more than three years anhydrobiotically, it could be gathered and stored for future use. Upon rehydration, the nematode becomes active within 30 minutes and could be applied to fiddleneck seedlings. We have observed that, although the nematode needs flowering plants to reproduce, it can feed on and may stress fiddleneck seedlings.

In March 1984, we completed a survey in central California of fiddleneck and the fiddleneck nematode. Before conducting the survey, we had consulted the herbarium at the California Academy of Sciences in San Francisco to determine where previous collections of the various fiddleneck species had been made. There are 12 species of *Amsinckia* in California, some of which are quite rare. We attempted to visit as many known collection sites as possible to determine the host range of the nematode.

Our results indicate that the host-parasite relationships are more complex than previously thought. For example, the nematode had been known to attack only common fiddleneck, *Amsinckia intermedia,* but we now know it attacks two other important weeds, *Amsinckia lycopsoides* and *A. gloriosa*. In addition, there may be different races of the nematode that are host-specific to different fiddleneck species or populations. What might be a particularly virulent strain of the nematode was found in the Santa Clara Valley, where the frequency and size of the flower galls were much greater than at other sites.

One question to be answered is why areas of nematode infestation are always localized and not more widespread. Investigations of the mode of the nematode's dissemination and the genetics of the host-parasite relationship may help to answer this question.

Gall midge

During our survey we also encountered a gall midge (*Schizomyia macrofila*) that feeds on fiddleneck and produces galls. Galls formed by the larvae are superficially similar to those formed by the nematode. However, the midge galls do not replace the flowers as do the nematode galls. Instead, almost any aboveground portion of the weed may form midge galls containing one or more orange-colored larvae. Full-grown larvae pupate in the soil and survive summer drought by aestivation. In the spring, the midges emerge as winged adults. Female midges lay eggs within the plant tissues of fiddleneck, and the developing larvae stimulate the host plant to form galls.

Few researchers have studied this gall midge, and its host range is not certain. Before our survey, only *Amsinckia lycopsoides* was reported to be a host. We found the midge on *A. intermedia* near Bakersfield and on *A. spectabilis* near Bodega Bay. The insect thus appears well adapted to habitats ranging from the desert-like climate of the southern San Joaquin Valley to the maritime climate of the northern California coast.

It is not known why the fiddleneck gall midge is not more abundant. Although not proven, an explanation might be that predaceous and parasitic insects are naturally controlling the gall midge, and it illustrates the complexities in the biology of a potential control agent. If natural enemies of the fiddleneck gall midge are limiting its numbers, a simple solution would be to release the midge after having removed the parasites. This approach would probably have only limited success in California, because the natural predators and parasites would eventually find the gall midge again. In areas geographically isolated from California, such as Australia or Europe, where fiddlenecks are also potentially important weeds, gall midge populations free of natural enemies might remain free and control the weed. We are currently making the fiddleneck gall midge available to researchers at the Commonwealth Institute of Biological Control (CIBC) in England and at the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Australia for use as a biological weed control agent.

Beneficial fungi

Pathogenic fungi may also have the potential to help control fiddleneck. At least four fungi attack fiddleneck: a leaf smut (*Entyloma serotinum*), a downy mildew (*Peronospora myosotidis*), a powdery mildew (*Erysiphe chichoracearum*), and a chytrid (*Synchytrium amsinckiae*). The leaf smut may have some of the desirable qualities of a fungal biological control agent: it causes disease after infecting the leaves; it has a limited host range; and its spores are resistant to sunlight and drought. The last characteristic is desirable because the spores can be harvested, stored, and applied at a later date.

In the western United States, the host range of *E. serotinum* is limited to fiddleneck and bluebells (*Mertensia*); both are in the family Boraginaceae. Because relatively few boraginaceous plants are cultivated, the danger of desirable plants being attacked by the leaf smut is minimal. Nevertheless, the impact of the fungus on the environment will need to be assessed. Additional unreported species might exist that are host-specific to fiddleneck, and the search for beneficial fungi needs to continue.

Summary

Studies are planned to elucidate the host-parasite relationships between fiddleneck and their nematode, insect, and fungal antagonists. Using native organisms to control a native weed poses some different problems than classical biological control, which usually involves foreign pests and introduced biological control agents. However, many of the principles are the same, and we believe that combining native organisms with chemical and cultural control methods could be effective, economical, and environmentally sound.

Dan James Pantone is Research Assistant, Division of Nematology, and a graduate student in the Graduate Group in Plant Protection and Pest Management, University of California, Davis; Stephen M. Brown is Assistant Research Nematologist, Division of Nematology, UC Davis; and Christopher Womersley is Assistant Professor of Zoology, Department of Zoology, University of Hawaii at Manoa.