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Biological Control of Western Gall Rust: Using a Beetle, *Epuraea obliquus* Hatch (Coleoptera: Nitidulidae), as a Vector for a Mycoparasite

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SUMMARY: Use of a beetle to disseminate a mycoparasite for biological control of western gall rust is examined. *Scytalidium uredinicola* Kuhlman et al. is an aggressive mycoparasite of western gall rust, *Endocronartium harknessii* (J. P. Moore) Y. Hiratsuka, which has promise as a biological control agent. The nitidulid beetle *Epuraea obliquus* is a natural vector for the mycoparasite, suggesting it could efficiently disseminate this mycoparasite for biological control of western gall rust. Also, *Epuraea obliquus* can have a direct impact on the population of western gall rust by feeding on spores. This method of biological control could be very effective, especially if integrated with other control procedures. The use of an insect to disseminate a mycoparasite could be considered in the biological control of other plant pathogens and pine stem rust diseases.

Key Words: biological control, western gall rust, *Endocronartium harknessii*, *Scytalidium uredinicola*, *Epuraea obliquus*.

INTRODUCTION

Plant pathogens can have disastrous effects on forest ecosystems. One management strategy for plant diseases is biological control. Augmentation of natural enemies has been the primary focus in biological control of plant pathogens and has much promise. Both insects and fungi are often effective at naturally regulating populations of plant pathogens (1, 4, 6, 13, 14, 20, 28). However, the use of natural enemies to control plant pathogens has had very limited success (4, 21, 22, 27, 29). This failure is not due to a lack of potential control agents, of which hundreds have been proposed (See 27), but is often related to implementation problems (12, 29).

A new biological control approach for western gall rust, a destructive pathogen of hard pines (8, 31), was proposed by Hiratsuka (7). He suggested that an insect which actively seeks out galls could efficiently disseminate a mycoparasite. This may overcome the difficulty of efficiently applying the mycoparasite, which has limited the success of other biological control programs (27). Although biological control agents might be sprayed in valuable plantations, this would be too expensive in large scale forestry operations.

We now discuss the most promising mycoparasite and insect for this biological control approach, and a new management strategy of which they are the focus.

CANDIDATE MYCOPARASITES

Three fungi are common parasites of western gall rust in western Canada and have potential in biological control programs. These are: *Scytalidium uredinicola* Kuhlman et al.; *Cladosporium gallicola* Sutton; and *Monocillium nordinii* (Bourchier) W. Grams (24, 25, 26). These mycoparasites significantly reduce the inoculum potential of western gall rust, deactivating a large proportion of older aged galls (parasitizing greater than 95% of the sporulating surface, Fig. 1).

Although all mycoparasites contribute to the natural control of western gall rust, *S. uredinicola* appears to be the most promising biological control agent. It was found to be the most abundant mycoparasite, being identified on more than 75% of the galls sampled near Hinton, Alberta (5, 26). *Scytalidium uredinicola* breaks down the basal cell region of the gall rust sorus and hyphae (26) and decreases spore germination (3). *Scytalidium uredinicola* also decreases spore production and spore germination of *Cronartium quercuum* f. sp. *fusiforme* in North Carolina and South Carolina (10).

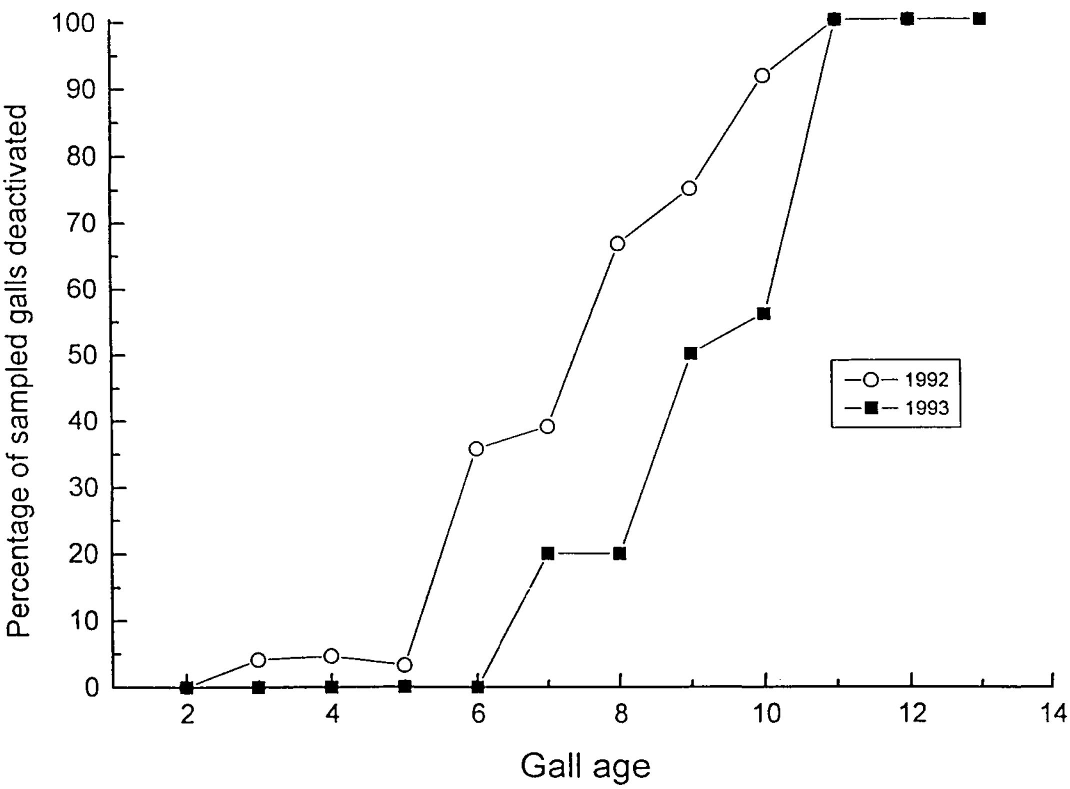

Fig. 1. Deactivation of different age galls of *Endocronartium harknessii* by mycoparasites near Hinton. Galls classified as deactivated had more than 95% of their sporulating surface parasitized by mycoparasite.

Table 1. Invertebrates commonly observed on western gall rust near Hinton, in 1992 to 1994.

Order	Family	Species
Coleoptera	Nitidulidae	*Epuraea obliquus*
"	Lathridiidae	*Melanopthalma* sp.
"	"	*Lathridius* sp.
"	"	*Corticaria* sp.
Lepidoptera	Pyralidae	*Dioryctria* sp.
"	Noctuidae	Unknown
Diptera	Sciarida	Unknown
Hymenoptera	Formicidae	several
Homoptera	Aphididae	*Cinara* sp.
Acari	Laelapidae	Unknown

CANDIDATE INSECT FOR DISSEMINATING MYCOPARASITE

Western gall rust acts as a diverse habitat for insects and mites. As many as 78 insect and mite species occur on galls in western Canada (18). Although many species were commonly collected from galls sampled near Hinton in 1992 and 1993 (Table 1) the most promising candidate for disseminating the mycoparasite is *Epuraea obliquus* (Coleoptera: Nitidulidae). This beetle is the most prevalent and abundant invertebrate occurring on western gall rust near Hinton (5).

The beetle has a close spatial and temporal association with western gall rust. Most of the life cycle occurs on the surface of galls during sporulation, with adults and larvae feeding on spores (5). Adults overwinter in the soil, emerging in the spring (late April to early May) to lay eggs on the surface of galls. The beetle has three larval instars, which all occur on the gall's surface with the last instar dropping to the soil to pupate (late June to early July). Larval activity occurs primarily during gall rust sporulation, and third instars drop from galls around the completion of gall rust sporulation. After pupation new adults return to galls to feed on the mycoparasites left on the surface. In late fall, they return to the soil to overwinter.

The use of this beetle would be effective in biological control because feeding by adults and larvae can significantly decrease the number of spores released by western

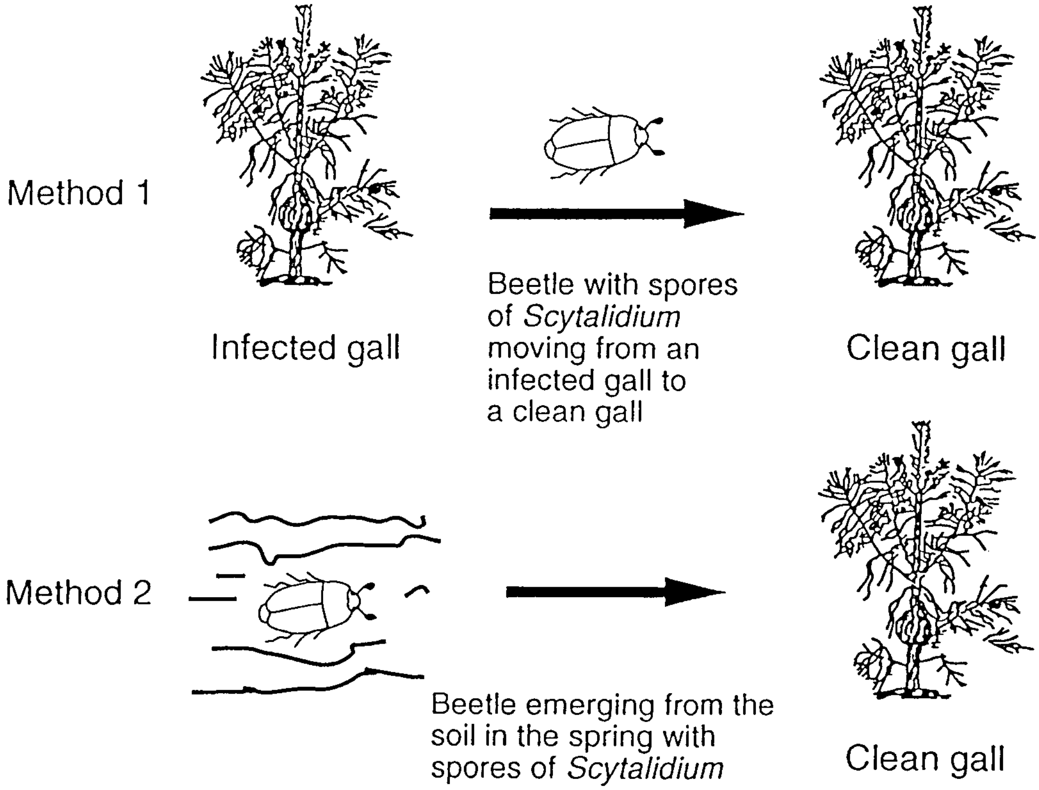

Fig. 2. Two methods which *Epuraea obliquus* can naturally vector *Scytalidium uredinicola*.

gall rust (5). Sori full of beetle frass are commonly observed, with no significant amounts of intact western gall rust spores remaining.

NATURAL VECTORING OF THE MYCOPARASITE BY THE BEETLE

Epuraea obliquus is a promising candidate for disseminating *S. uredinicola* because it is a natural vector for the mycoparasite (5). This beetle can disseminate the mycoparasite in two different ways (Fig. 2). First, beetles can transfer the mycoparasite from parasitized galls to unparasitized galls by flying between galls during the season. Secondly, beetles can carry spores from the previous year to unparasitized galls when they emerge from the soil after overwintering. These beetles were likely inoculated with spores of the mycoparasite while feeding on galls in the fall.

Epuraea obliquus likely acts as a natural vector for *S. uredinicola* on three spatial scales. On the smallest scale, beetles could disseminate the mycoparasite across the surface of individual galls. On a larger scale, beetles may transfer the mycoparasite to new galls within stands, or lastly, from stands with mycoparasite to new uninfected stands.

This biological control approach has the possibility of long term control of the western gall rust. The mycoparasite and beetle could reproduce and provide control in later generations, which may not have been achieved with initial releases. Both the inoculum source for the mycoparasite and the population of natural vectors will be increased, thus providing better natural control of western gall rust.

MANAGEMENT PROGRAM

An augmentative biological control approach, releasing large amounts of beetles and mycoparasites yearly over large forest areas, would be very expensive and not economically feasible. Inundative biological control, a single release of natural enemies to establish long term control, would be cost effective if it significantly reduced the population of western gall rust. Single releases of *E. obliquus* inoculated with *S. uredinicola* could provide long term control within stands because these natural enemies of western gall rust are self perpetuating. Also, Bella and

Navratil (2) have shown that the incidence of western gall rust in stands less than 12 years old is only about 5%, while it increases rapidly before leveling off at 20% at stands ages of 20. The processes driving the increase in gall rust in these stands is not understood. If an absence of natural enemies in the sites during these years contributes to the exponential population growth of western gall rust, inundative releases of the beetle and the mycoparasite could effectively limit this pathogen's population growth. Additionally, in sites which are at high risk for western gall rust epidemics, such as those on east-facing slopes and at elevations between 1200 and 1400 m (2), multiple releases could be prescribed during early years of western gall rust infestation.

Although this approach is promising and may provide some control of western gall rust, it must be integrated with other control procedures for full effectiveness. Silvicultural practices such as adjusting stand densities to reduce the impact of western gall rust, and pre-commercial thinning and pruning of diseased trees could be successfully integrated with this biological control approach. Also, development of seedlots resistant to western gall rust could increase the effectiveness of this control procedure.

USE OF THIS APPROACH FOR OTHER PLANT PATHOGENS AND PINE STEM RUSTS

Insects and mycoparasites are commonly associated with pine stem rusts in North America. *Epuraea obliquus* is also found on western gall rust in the northwestern United States and has been located in parts of eastern Canada on Jack Pine (*Pinus banksiana* Lamb.). Although *S. uredinicola* has not been identified from many of these regions, this or other mycoparasites are likely present. *Epuraea obliquus* is also found on comandra blister rust, (*Cronartium comandrae* Peck) and *Cronartium coleosporioides* Arth. occurring on lodgepole pine in western Canada (17) but it has not been established whether the mycoparasite occurs on these other pine stem rusts. *Phalacropsis dispar* (LeConte) (Coleoptera: Phalacridae) occurs abundantly on many pine stem rusts in the midwestern United States (13). *Scytalidium uredinicola* and another nitidulid beetle, *Epuraea lengi*, occurs on *Cronartium quercuum* f. sp. *fusiforme* on loblolly and slash pines in North Carolina and South Carolina (11). The interactions of these insects and fungi likely play important roles in the natural regulation of pine stem rust populations. Perhaps this combination of mycoparasites and insects can be used in biological control programs for other pine stem rusts in North America.

The use of an insect to vector a mycoparasite has had some success in other systems. Peng et al. (15) increased transmission of the mycoparasite of *Botrytis cinerea* Pers. (gray mold) on the flowers of strawberries using bees. Bees, inoculated as they came out of their hives, provided efficient and constant application of the control agent. Bees are also efficient vectors for bacteria (*Pseudomonas fluorescens* and *Erwinia herbicola*) antagonistic to fire blight, *Erwinia amylovora* (9, 23). Other insects have been used to disseminate control agents for weeds. Quimby and Frick (19) used herbicide-coated larvae of the nutsedge moth and American waterhyacinth borer moth for improved control of these weeds. Also, some insects released to control a weed have unintentionally promoted a pathogen, thus reducing the weeds population (16, 30). Thus pathogen/insect vector systems may be effective in many different biological control programs.

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