A NEW STRATEGY FOR THE BIOLOGICAL CONTROL OF PINE STEM RUSTS

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INTRODUCTION

As a group, pine stem rusts are considered the most important forest tree disease problem in Canada (Whitney et al. 1982). There is extensive documentation pointing out their significance in intensively managed Canadian pine forests (Baranyay and Stevenson 1964; Bella 1985a, 1985b; Carlson 1969; Hiratsuka 1981; Hiratsuka and Powell 1976; Hiratsuka et al. 1988; Johnstone 1981; Powell and Hiratsuka 1973; Ziller 1974). Development of effective, economically feasible, and environmentally acceptable control and management strategies of the pine stem rusts is important for successful cultivation of pines.

Although breeding for rust-resistant planting stock in conjunction with tree improvement programs may be the ultimate solution for controlling this group of diseases, there are many obstacles and unknown factors to be considered before any practical results can materialize from this approach. Chemical control of certain species in specific cultural conditions can be justified (Kistler and Merrill 1978; Merrill and Kistler 1976a, 1976b), but the results are often inconclusive (Leaphart 1963), economically unfeasible, and environmentally unacceptable in most forestry situations. Silvicultural controls such as alternate host eradication (Offord et al. 1958), and pruning of lower branches (Hunt 1982) have been suggested but results are not always clear.

Biological control can be considered as an alternate strategy for controlling this group of pine diseases. Several aggressive mycoparasites and other fungi and bacteria associated with pine stem rusts have been identified and investigated (Ayer et al. 1980; Bergdahl and French 1978; Byler and Cobb 1969; Byler et al. 1972a, 1972b; Hiratsuka et al. 1979; Kuhlman et al. 1976; Pickard et al.1983; Powell 1971b, 1971c, 1972a; Tsuneda and Hiratsuka 1979, 1980, 1981b; Tsuneda et al. 1980; Wicker and Wells 1968). Possible roles of these mycoparasites in the epidemiology of pine stem rusts and the possibility of their use in the biological control of those fungi have been suggested and discussed (Byler et al. 1972a; Hiratsuka 1979; Hiratsuka et al. 1987; Powell 1971e; Powell 1974; Quick and Lamoureux 1967; Tsuneda and Hiratsuka 1981a). One of the biggest obstacles of this approach is the difficulty of effectively delivering selected hyperparasites to the target organisms.

Insects and other free-moving organisms such as mites and slugs are known to feed on pine stem rust spores and rust-infected tissues. It is suspected that these organisms play a significant role in the epidemiology of the diseases caused by the rusts (Myren 1964; Nelson 1962, Powell 1971a; Powell 1971d; Powell 1972b; Powell 1974; Powell and Skaley 1975; Powell et al. 1972; Snell 1919; Wong 1972).

PROPOSAL FOR A NEW STRATEGY

This proposal is a new strategy for biological control of pine stem rusts with aggressive hyperparasites using certain free-moving organisms (mainly insects) as possible vectors of hyperparasitic microorganisms. If these vectors are species which actually seek the target organisms (pine stem rusts) and feed on the rust sori, we can potentially contaminate these vectors with active propagules of hyperparasites and release them into the areas with high rust populations.

CANDIDATE ORGANISMS

With this new strategy in mind, literature searches, field surveys, and laboratory examinations involving western gall rust were conducted in order to find suitable candidate vectors and mycoparasites.

Among the insects and other free-moving organisms recorded on western gall rust and other pine stem rusts by Nelson (1982), Powell (1971a), Powell and Skaley (1975), and Powell et al. (1972), several frequently identified species seem to feed selectively on pine stem rusts. They are *Mycodiplosis* spp. (Diptera: Cecidomyiidae), *Phalacropsis dispar* (LeConte) (Coleoptera: Phalacridae), and *Epuraea obliquus* Hatch (Coleoptera: Nitidulidae) (Fig. 1). At the present time, the most promising insect candidate is *E. obliquus*. This species and other nitidulids are known to feed on tree sap and associated fungi (Hatch 1952; Parsons 1967).

The best candidate mycoparasite is *Scytalidium uredinicola* Kuhlman, Carmichael and Miller. This is one of the several aggressive mycoparasites of western gall rust identified from previous work (Hiratsuka et al. 1979; Tsuneda and Hiratsuka 1979, 1980, 1981a, 1981b; Tsuneda et al. 1980). This fungus parasitizes immature spore layers as well as mature spores and is capable of destroying the entire spore crop for the year.

There are strong indications that *E. obliquus* is the main vector of *S. uredinicola* and other mycoparasites in nature. The beetle can carry spores of *S. uredinicola* on most of its body surfaces, especially on areas having setae (Figs. 2, 3).

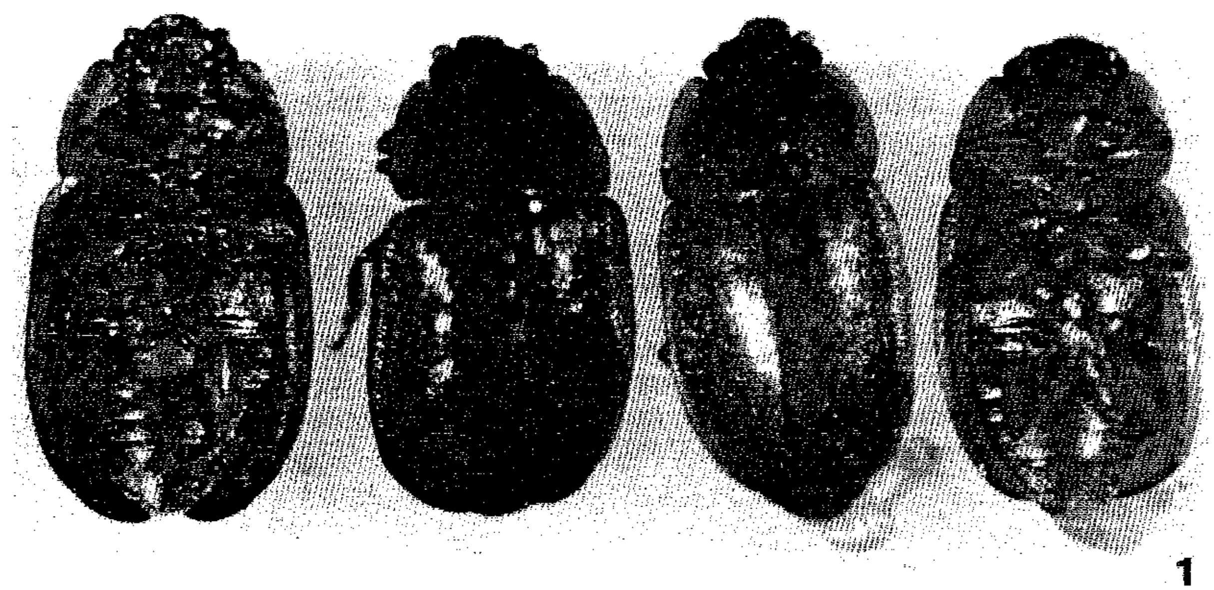
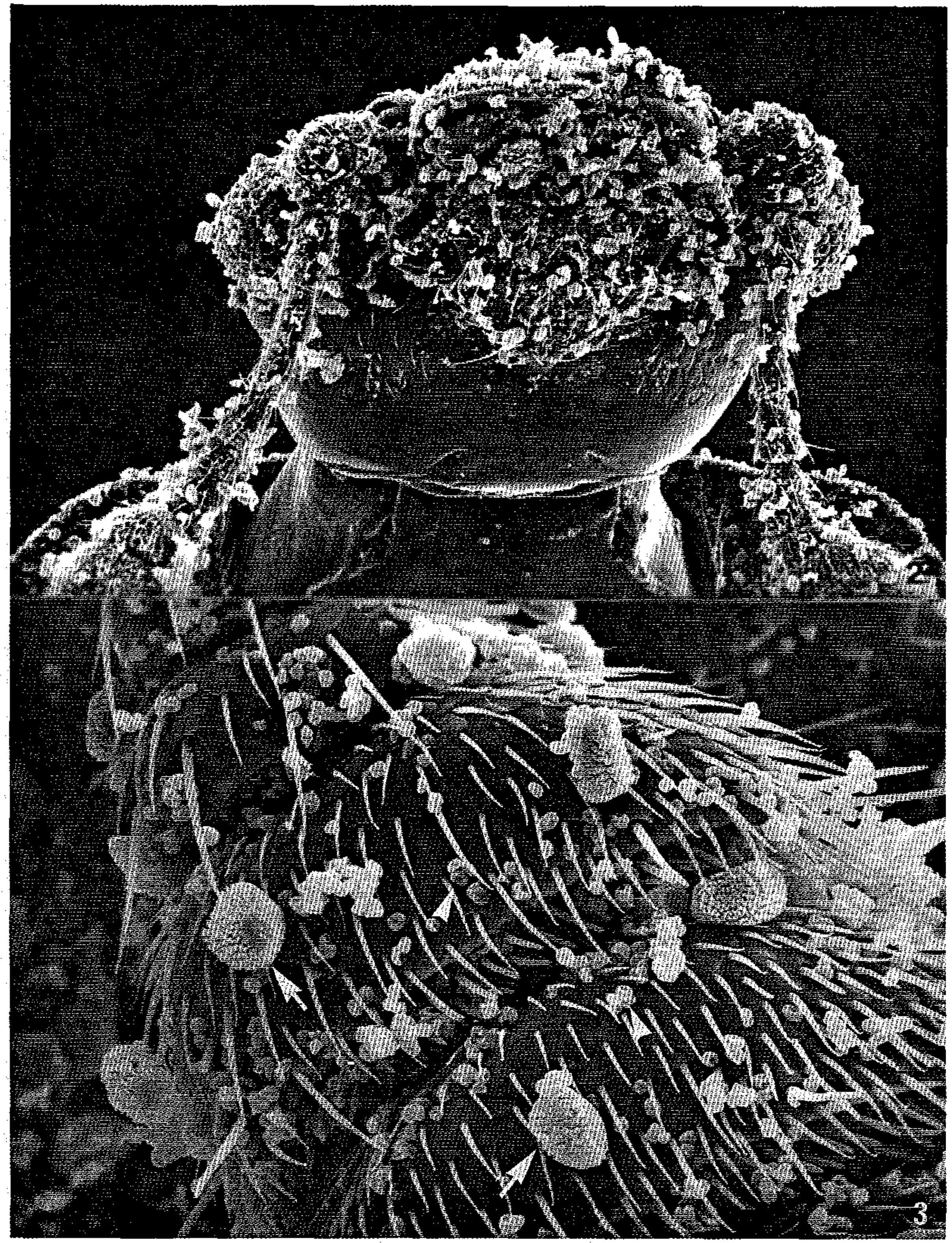


Figure 1. Adults of *Epuraea obliquus* (× 30).



Figures 2-3. **2.** A head of *Epuraea obliquus* (× 90). **3.** Spores of *Endocronartium harknessii* (large spores, arrows) and spores of *Scytalidium uredinicola* (smaller spores, arrowheads) on an antenna of *Epuraea obliquus* (× 400).

LIFE CYCLE OF *EPURAEA OBLIQUUS*

The life cycle of *E. obliquus*, as suggested by preliminary observations made in Hinton, Alberta, area in 1988 and 1989 is as follows. Overwintering adults emerge from the duff in early June to seek rust galls. After a few days of feeding on rust spores, the adults mate and lay eggs in the rust sori. The eggs hatch in a few days, and the larvae start feeding on rust spores. After 2-3 weeks, larvae mature (by the time most of the spores are consumed by the larvae) and drop to the ground. The larvae move under the duff layer just above the mineral soil where they pupate a few weeks later, and in another few weeks emerge as adults and remain in the duff where they then enter diapause.

CONCLUSIONS

This new biological control strategy for plant pathogens, using aggressive microbial hyperparasites with certain free-moving, target-seeking organisms (mainly insects) as vectors (Fig. 4), has much merit and can be applied to various pathogen-hyperparasite systems in forestry and agriculture. A joint investigation involving an entomologist (J. Volney, Northern Forestry Centre, Forestry Canada, Edmonton, Alberta), a natural product chemist (W.A. Ayer, Department of Chemistry, University of Alberta, Edmonton, Alberta), and a forest mycologist (Y. Hiratsuka, Northern Forestry Centre, Forestry Canada, Edmonton, Alberta) has been proposed to develop this idea further.

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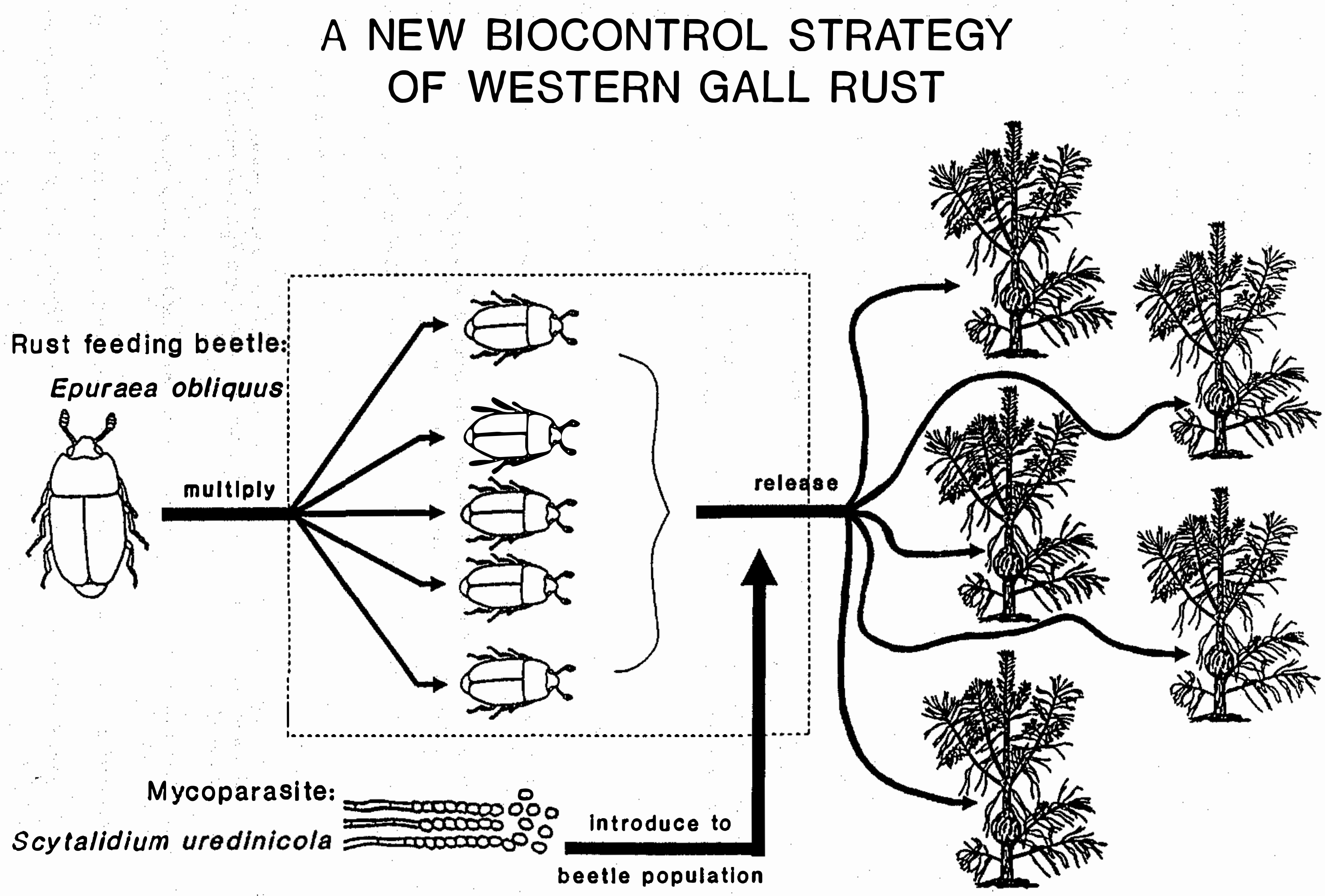

Figure 4. A schematic drawing of the new biocontrol strategy of western gall rust.

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