The species ranges through temerate eastern America from the outhern New England states south to lassachusetts and New York, west to lichigan, Wisconsin and Minnesota, orth to southwestern Quebec, and est to southcentral Manitoba. It ocurs in Saskatchewan as disjunct opulations.

It is hoped that this rare orchid will ot succumb to overzealous collectors r vandalism. Although some efforts re being made to protect the species t Hudson Bay[5], the author strongly rges that *all* our native orchids be laced on the list of protected native flora soon before it is *too* late.

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THE ROLE OF NATURAL BIOLOGICAL AGENTS IN CONTROLLING A PINE STEM RUST (*CRONARTIUM COMANDRAE*)

by JOHN M. POWELL*

The stem or blister rust fungi are mong the most destructive and angerous diseases of pines. Six ecies of these rusts are found in anada, five of which occur in the rairie Provinces. The best known is e introduced white pine blister rust hich attacks the five-needle or white nes. The others are native and occur n the two-needle or hard pine group hich includes jackpine (*Pinus nksiana* Lamb.) and lodgepole pine (*P. contorta* Dougl. var. *latifolia* Engelm.). One of the native rusts is the Comandra blister rust (*Cronartium comandrae* Pk.) which is found across Canada[1] and over much of the United States, and now has been reported infecting 15 species of pines in North America[6]. This rust has been the subject of a 6-year study carried out largely in southwestern Alberta where it occurs on lodgepole pine. One objective of the study was to assess the role of various biological agents, namely the macro- and micro-fauna and micro-flora, on the production of rust spores and whether rust cankers

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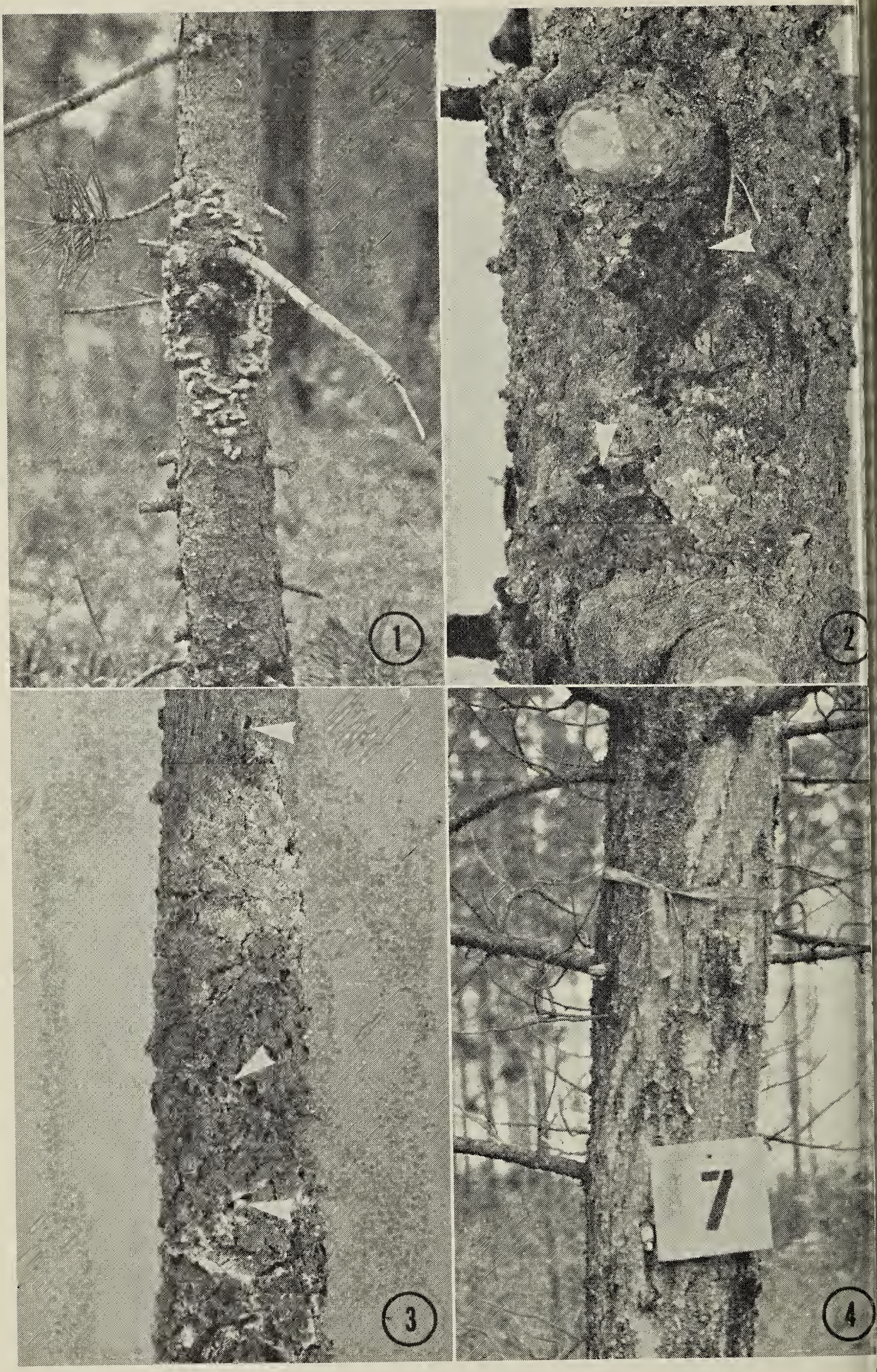

Figs. 1 to 4. Cankers of comandra blister rust on lodgepole pine.

ay be inactivated through the action some of these biological agents.

The Comandra blister rust fungus s five spore forms which are oduced in succession and it takes 2 more years to complete its life cle, for, like most rusts, it requires o distinct host plants to complete its cle. The rust fungus grows perenally in the living bark of pines, its imary host, and causes a swelling d canker. The rust annually oduces its spermogonial and aecial ore states along the edges of the nker (Fig. 1). The spermogonial ore state is the sexual spore stage of rust which produces masses of inute spores (called spermatia or cniospores). The spores exude from spermogonia (structures that bear sex organs) in orange gelatinous oplets in mid- or late summer. The cial spore state develops from mid-ay to August on the same area of the rk where the spermogonia were oduced the previous year. The aecia blister-like fruiting bodies, which e the disease its name, push through bark tissues to rupture and release wdery masses of small, pear-shaped ange-yellow spores (aeciospores, g. 5) which are dispersed by the nd. These aeciospores may land on sceptible alternate hosts, i.e., the rennial herbs comandra or bastard ad-flax (*Comandra umbellata* and *ocaulon lividum*), germinate and gin the next succession of spore tes on these plants, thus completing life cycle of the fungus.

Cankers of the rust usually persist branches and trunks of pines for many years before growth of the rust around the stem kills the branch or tree, or the canker is inactivated. Some cankers have been found that were 100 years old and still growing. They may grow to a length of several feet. The centre or older portion of the canker is composed of cracked, rough dead bark tissues, killed by the rust.

Rust cankers provide a suitable habitat for the development of certain fungi and arthropods. Over a period of several years the fungi, bacteria, spiders, mites and insects found associated with the cankers and spores were collected and identified. Observations were made on the incidence of these organisms and their effect on cankers and on spore production. The incidence of rodent damage was also noted, for the swollen infected bark, which has a high concentration of sugars, is very attractive to rodents. The causes of canker inactivation were also recorded.

A total of 56 species of fungi and 8 bacteria was identified[2]. A purple mold (*Tuberculina maxima*) (Fig. 2) and an undescribed dark green fungus (*Cladosporium* sp.) were most common and played an important role in reducing aeciospore production. The purple mold is parasitic on the rust canker and occurred on 20 to 55% of the active cankers depending on the year. It prevented spore production on 10 to 15% of the potential aecial-producing tissues in any one year and was the main cause for inactivation on about half the cankers[3]. Certain species of *Cladosporium* are parasitic on the aeciospores and occurred about

g. 1. Aecial pustules (blisters) of the rust rupturing to release spores.

g. 2. Canker infected with the purple mold (*Tuberculina maxima*) which is conspicuous as a darker area where the surface bark has been removed or cracked (see arrows).

g. 3. Typical rough bark of canker showing evidence of insect damage. Note exit holes and Lepidoptera frass (refuse left by boring insects) at top of canker and further frass in lower rough zone (see arrows).

g. 4. Annual squirrel damage on a large canker. Note the strip of dried dead bark not removed each year, and the abundant exudation of resin.

Fig. 5. Aeciospores with typical tail of species (magnified 650 times).

half as frequently as the purple mold. Several of the other fungi and bacteria, especially some *Penicillium* spp., *Arthrobacter* spp., *Pseudomonas* spp. and *Rhodotorula* spp., were commonly found. These also affected aeciospore viability [2 5].

A large number of arthropods were collected from the cankers, representing 143 species of insects, 19 mites and 4 spiders [4 7]. The insects damaged 41 to 62% of the cankers observed in any one year and reduced aeciospore production by 10% (Fig. 3). Three species appeared to depend exclusively on the host fungus for food during at least their larval stages. These were a nitidulid beetle (*Epuraea obliquus*), a cecidomyiid fly (*Mycodiplosis* sp.) and a drosophilid fly (*Paracacoxenus guttatus*). These species feed extensively on the spores but do little damage to the underlying infected bark tissue. Other species, notably the twig weevils (*Cylindrocopturus deleoni* and *Pissodes schwarzi*, Fig. 6) and larvae of the cone moth (*Dioryctria* spp., Fig. 7, an *Laspreyresia* spp.), needleminer moth (*Eucordylea* spp.) and an olethreuti moth (*Grapholitha* sp.) fed among th spore masses and then mined exten sively into bark tissues destroyin large areas of the aecial and sper mogonial zones of the canker. Other also did damage or fed on the spore but many of these could be classifie as only occasional visitors, no regularly associated with the rust.

Rodents caused extensive damage t the cankers through removal of th rust-infected bark down to the sap wood, usually in winter and spring although there was some chewin throughout the summer and early fal In some areas there was extensiv damage every year, so that aeciospor production was minimal (Fig. 4) Squirrels, rabbits and hares wer responsible for most of this extensiv damage, although porcupines, chip munks and mice were also responsibl for some of the bark removal. Th rodents usually restricted their ac tivity, except in the case of porcupines to the infected bark, often removin all the spermogonial and some of th aecial zone, completely ringing the ol portion of the canker. Often over 90% of the infected trees in a pine stan have been scarred by rodent chewin Nearly 500 cankers were kept unde

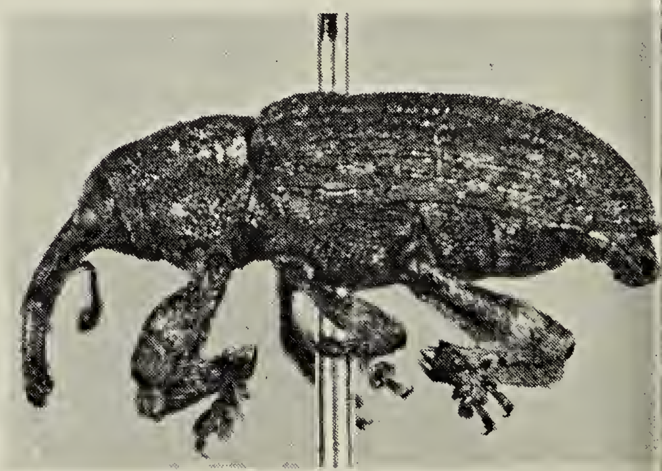

Fig. 6. Adult *Pissodes schwarzi* (side view length: 6 mm.).

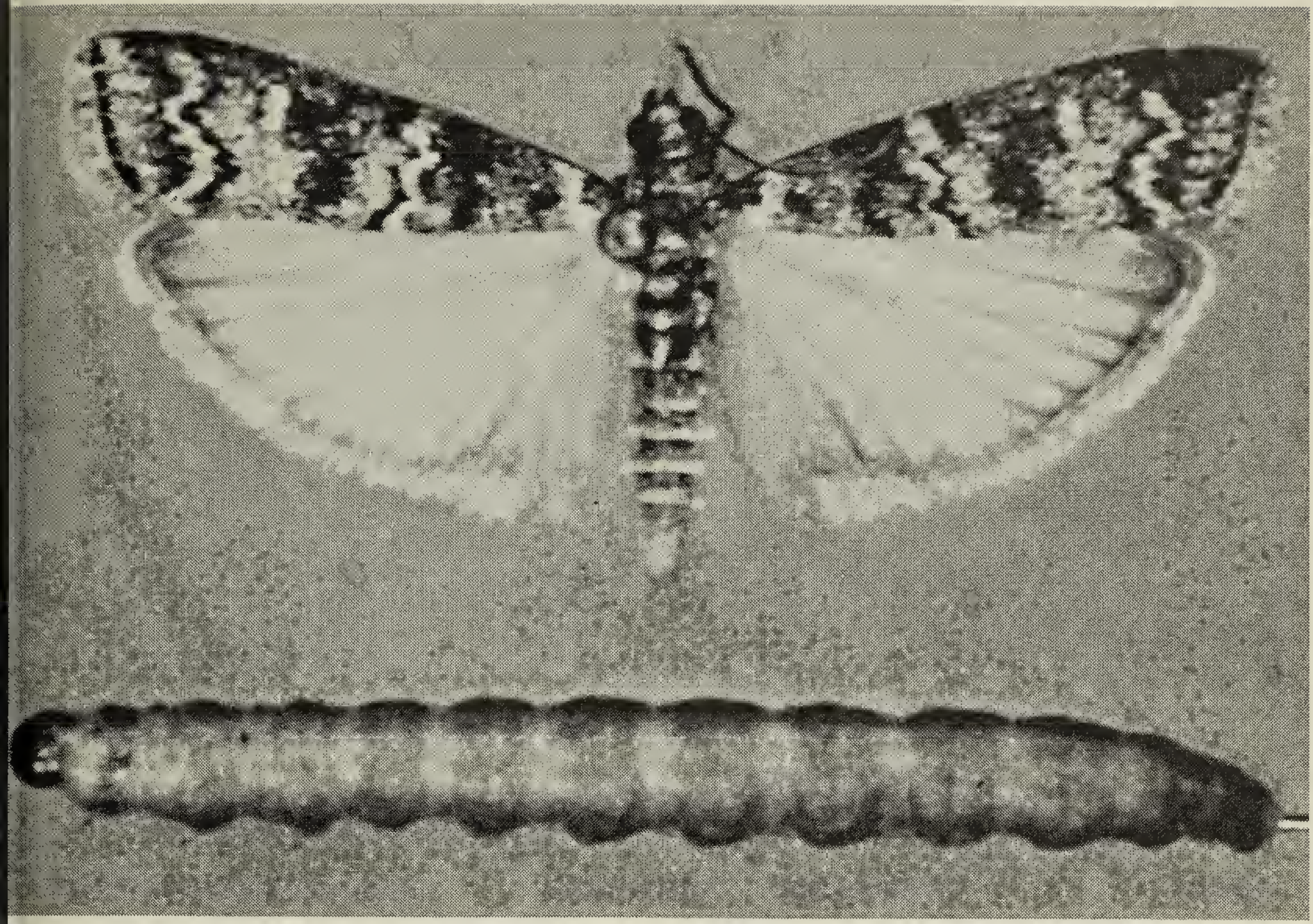

Fig. 7. Adult and larvae *Dioryctria abietivorella* (wing span: 28 mm.).

bservation for 6 years in 20 different tands in southwestern Alberta. In any ne year 25 to 52% of the active ankers were gnawed. Rodents educed the potential aecial producing ark tissues by 30% in any one year, nd some 17% of the cankers were nactivated.

Together these biological agents ere responsible for destroying 55% f the potential spore production on ine in any one year. The purple mold *Tuberculina maxima*) and the rodents, ere responsible for over 60% of the ust cankers which were inactivated, lthough this was often a slow process nd total canker inactivation took nany years. These natural biological ontrol agents, therefore, play a very nportant role in keeping the comanra blister rust (and other pine stem usts) under control; without them we ould be faced with far bigger rust isease problems in forest nanagement, especially with our increasing trend towards intensively managed forests.

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