Increase of Dwarf Mistletoe Infections on Young Lodgepole Pine

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Field studies in southern Alberta revealed a rapid increase in the incidence of dwarf mistletoe (Arceuthobium americanum Nutt. ex Engelm.) in young lodgepole pine (Pinus contorta Dougl. var. latifolia Engelm.). In 10 areas of infected trees, the number of infections increased exponentially at a mean rate (base 10 logarithm) of 0.24 per year (range: 0.19-0.29 among areas). Differences in rates of increase among areas were not significant.


A mesure que les arbres prennent de l'âge, le taux d'infection de jeunes Pins lodgepoles (Pinus contorta var. latifolia Engelm.) par le Faux-Gui américain (Arceuthobium americanum Nutt. ex Engelm.) augmente rapidement dans le sud de l'Alberta. Parmi les dix foyers d'infection étudiés, le nombre d'infections augmentent exponentiellement au taux moyen (logarithmes de base 10) de 0.24 par an (extrêmes: 0.19-0.29). Les différences de taux d'un foyer à l'autre n'étaient pas significatives.

Introduction

Dwarf mistletoe (Arceuthobium americanum Nutt. ex Engelm.) is an important widespread pathogen of lodgepole pine (Pinus contorta Dougl. var. latifolia Engelm.) in western Canada (1, 10, 13). Dwarf mistletoe seeds germinate and by means of a radicle penetrate into host tree bark. After 2-4 years (4,6) the host bark and wood around the site of penetration become swollen, and aerial shoots of dwarf mistletoe grow from the swollen bark. Flowers and seeds on pistillate shoots develop after another 2-3 years (6). The association of dwarf mistletoe and host tissues which results in a localized swelling is called an infection; the association, before swelling occurs is called a latent infection; and trees which bear infections are considered to be infected. When trees are infected at an early age, dwarf mistletoe parasitism and abnormal growth of colonized host tissues significantly reduce the growth of bole wood (2,4,9).

Because of the impact of dwarf mistletoe on tree growth, control of the pathogen in or near stands of young trees is recommended (2,4,8,9,13). Young trees established from seed after logging or burning are initially free of dwarf mistletoe, but in 30 years 100% of the young trees situated 30 ft (9 m) or less from residual trees of the previous forest can be infected (8). Thus the main strategies to control dwarf mistletoe are to prevent spread of dwarf mistletoe from residual to young trees, and to eradicate, by pruning or felling, dwarf mistletoe infections on young trees.

Results of previous studies of other plant pathogens and diseases showed that detailed knowledge of epidemiology of disease, which includes the population dynamics of the pathogen (16), would facilitate evaluation of control treatments and formulation of new control strategies (11,12,16,17). For example the efficacy of a treatment to eradicate infections depends in principle on the proportion of infections destroyed and on the rate of increase of new infections (16). Previous studies of dwarf mistletoe spread, increase of infections, and increase of proportion of trees infected were based on extensive surveys of infected trees of various ages (8,9). The ability to estimate the age of individual dwarf mistletoe infections (8,9,15) and the limited spread of dwarf mistletoe in an even age young forest of lodgepole pine in southwest Alberta, provided an opportunity to determine the increase of dwarf mistletoe infections in particular areas. The present study was undertaken to determine increase
of numbers of infections with time, expressed as average tree age for convenience, in areas of infected young trees.

Methods

Increase of dwarf mistletoe infections was determined in 1965 and 1966 in an even age (average 26 years) forest of lodgepole pine in the East Slope Rockies Section of the Subalpine Forest Region (14) at 5200-6000 ft (1580-1830 m) elevation and 50-60 miles (80-100 km) west of Calgary, Alberta. The young forest was established after a wild fire in 1939 which destroyed most of the previous forest of lodgepole pine and white spruce (Pinus silvestris (Moench) Voss.). Scattered remaining pine, approximately 70 years of age, infected by dwarf mistletoe were sources from which dwarf mistletoe had spread into the surrounding young trees. About 100 separate areas of young infected trees were located and rated as having a high incidence of infections, several thousand per area, or a low incidence, 100 or fewer infections. Seven areas of high, and three of low, incidence were randomly selected from the respective groups of areas. In each high-incidence area, a square grid of coordinates was surveyed at a spacing of 10 × 10 ft (3 × 3 m), and all infections within a radius of 5 ft (1.5 m) of each randomly selected coordinate were collected. Approximately 450 infections were collected in each of the areas. In the low-incidence areas all infections were collected.

The age of each infection was estimated by dissecting and counting the number of annual wood rings in which dwarf mistletoe sinkers were embedded (5,15). Because the period between penetration of bark and penetration of sinkers into the wood, possibly 1–2 years (8), was unknown for infections in Alberta, the age of infection was not adjusted for this period. The age of each infection was subtracted from 26, the average age (range 18–27 years) of the trees, to transpose age of infection to time (tree age) at which infections were established. The rate of increase of infections was analyzed by appropriate graphical and statistical techniques (3).

Fig. 1. Average number of dwarf mistletoe infections in relation to average tree age in areas with high and low incidence of infections (range in data indicated by vertical lines).
Results

The average increase of numbers of infections per year, where time is expressed as average tree age, for areas of infected trees of both high and low incidence of infections, is shown in Fig. 1. In some areas, particularly those of low incidence, the initial increase was slow, but from 16 to 23 years increase was very rapid. Few infections of age 3 years and less, which corresponds to average tree age of 23 years or more, were found.

In each area, a highly significant linear regression was found between the logarithm (base 10) of the number of infections \(Y\) and average tree age \(X\) from 16 to 23 years. The regressions accounted for 89-99% of the total variability of \(Y\). I conclude that the number of infections increased exponentially in each focus.

The rates of increase, defined by the slope or regression coefficient of each regression (3), ranged from 0.19 to 0.29 per year among areas. The differences among rates, although large, were not statistically significant. Possibly, significant differences were obscured by the variation of \(Y\) in each regression. The weighted mean rate, 0.20, in three areas of low incidence was slightly less than that, 0.24, in seven areas of high incidence (Fig. 2). However, the two types of areas were sampled differently, and the difference between the two rates, although statistically significant, might be accidental.

Discussion

These results show rapid increase of dwarf mistletoe infections in areas of young infected trees in southern Alberta. Hawksworth (7) found that infections of *A. occidentale* Engelm., established by inoculation, also increased rapidly in number. The mean rate of increase of 0.24 found in the present study represents an increase of 74% compounded annually or a generation time (period in which infections double in number) of 1.25 years. Eventually, the exponential increase will probably be limited in older stands by various factors (16).

The similar average rates of increase among high- and low-incidence areas (Fig. 2) indicate that differences in incidence of infections were mainly the result of earlier unknown events. Although the methods of this study were not designed to examine the

![Fig. 2. Regressions and numbers of dwarf mistletoe infections in relation to average tree age in areas with high and low incidence of infections.](image)
early stages of spread into, and increase within, the areas, and an unknown proportion of the earliest infections established in the areas have died, these results suggest that the initial increase of infections was slow, particularly in areas of low incidence (Fig. 1). Possibly in these areas the initial spread of infections into the young trees or the establishment of sufficient infections to permit exponential increase occurred only recently. The early stage of spread and increase of infections in young trees should be investigated because of the opportunity for more effective control at this stage.

Two aspects of dwarf mistletoe epidemiology indicated by these results which should be considered in determining strategy and evaluating methods for silvicultural control of the parasite on young trees are: (1) the presence of a large number of latent infections because of the rapid increase of infections and the 2–4 year period necessary for the appearance of infections, and (2) the potentially rapid increase of infections from low levels of incidence. Thus either thorough eradication of all infections or partial eradication combined with treatment to suppress the increase of remaining infections may be necessary to achieve lasting control.

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