BUILD-UP OF PULLULARIA PULLULANS (deBary) BERKHOUT WITHIN A SEVERE SPRUCE BUDWORM INFESTATION AT BABINE LAKE, BRITISH COLUMBIA [1]

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ABSTRACT

A report of bud necrosis of white spruce, Picea glauca (Moench) Voss, within spruce budworm, Choristoneura fumiferana (Clem.), infested stands was investigated. No significant differences in bud mortality could be determined between infested and non-infested stands, but a nine-fold higher incidence of Pullularia pullulans (deBary) Berkhout was measured in infested stands. This later finding suggested a marked build-up of the fungus as a result of conditions created by the budworm infestation.

INTRODUCTION

Native forest disease fungi generally exist at an endemic level of abundance varying relatively little in intensity of infection from year to year. The height of this endemic disease level is controlled largely by the factors which govern stand vigor, that is, site quality, stand age, and stand history. These factors not only circumscribe the vigor of host development but also the biotic and edaphic factors which control the reproduction and subsequent development of their associated fungus flora. In a given stand, disease fungi will continue at an endemic level, with minor adjustments related to stand development, unless some disturbance occurs to upset the existing biological equilibrium. The present paper illustrates such a disturbance where a major spruce budworm outbreak conditioned a marked build-up in the population of the fungus, *Pullularia pullulans*.

Surveys in 1956 and 1957 determined the location of a severe spruce budworm outbreak at the upper end of Babine Lake in the Prince Rupert Forest District of British Columbia. During routine sampling to measure budworm population levels and the condition of affected stands in 1957, branch samples from white spruce indicated a heavy mortality of buds from causes other than insect damage. Further samples of white spruce buds collected in October, 1957,

[1] Contribution No. 553 from the Forest Biology Division, Research Branch, Department of Agriculture, Ottawa, Canada. Received for publication April 29, 1959.

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exhibited a slight tip browning when sectioned, and following surface sterilization the fungus *Pullularia pullulans* was isolated from over 80 per cent of them. A further check of buds collected from a white spruce plantation near Cowichan Lake, remote from any budworm infestations, revealed the tip browning to be a usual feature of white spruce buds, but *Pullularia* could not be isolated from these buds.

While the observed tip browning was apparently not diagnostic of a disease condition, the absence of *P. pullulans* in the Cowichan Lake sample and its high incidence in the buds obtained from within the area of spruce budworm infestation suggested the possibility that buds may have become infected during a late stage of development on trees badly weakened by budworm feeding. Studies were begun to determine if *P. pullulans* occurred at higher population levels in areas of heavy budworm infestation than in uninfested stands in the same region, and to assess the nature and significance of the reported bud mortality.

Results

Incidence of *Pullularia pullulans* in white spruce buds

Isolations were made in 1.5 per cent potato dextrose agar from monthly collections of white spruce buds obtained throughout the winter and spring from within and near the spruce budworm infestation at Babine Lake. The results of these studies indicated a marked difference in the occurrence of *Pullularia* between infested and non-infested stands (Table 1). The incidence of *Pullularia* on the buds from infestation areas averaged nine times higher

TABLE 1

Incidence of *Pullularia pullulans* on White Spruce Buds In Relation to Intensity of Spruce Budworm Infestation

Moderate to heavy infestation					Nil to light infestation			
Sample number	Degree of infestation	Number buds in sample	Percentage with P. pullulans	Month of collection	Sample number	Degree of infestation	No. buds in sample	% with P. pullulans
A	Heavy	32	98	October	—	—	—	—
B	Heavy	32	85	October	—	—	—	—
C	Heavy	32	94	October	—	—	—	—
1	Moderate	20	75	November	3	very light	24	8
2	Heavy	36	89	November	4	nil	32	9
6	Moderate	28	64	November	5	nil	20	5
—	—	—	—	December*	7	nil	24	0
9	Moderate	60	40	January	8	nil	60	3
10	Moderate	60	65	February	11	nil	60	5
12	Moderate	60	43	March	13	nil	60	22
14	Heavy	60	92	April	15	nil	60	12
16	Heavy	60	70	May	17	nil	60	11
Average			74					8

*Cowichan Lake sample to check significance of bud tip browning. All other samples were collected within and near the Babine Lake infestation.

than that obtained outside the infestation. The maximum incidence of the fungus outside the infestation was just over one-half of the minimum incidence inside.

Pullularia pullulans was isolated from 100 per cent of a sample of 128 dead buds encountered during field examinations in the spring of 1958. Similarly, the fungus was isolated from all of 200 single pellets of spruce budworm frass planted on potato dextrose agar plates, suggesting at least one important reason for the much higher incidence of *P. pullulans* within the budworm infestation. External hyphae of the fungus produced a heavy mold-like growth on twigs and branches of infested trees. Fungi, other than *P. pullulans,* were also isolated from the monthly bud samples, as they were in the later isolation experiments, but their occurrence was sporadic.

Significance of Bud Mortality

During cultural studies of the monthly bud collections, buds were surface sterilized, one-half of each bud being planted on agar while the other half was kept under observation for any pathological symptoms that might develop. During macroscopic and microscopic examination of buds, fungus hyphae were commonly present between the scales and in dead cells outside the primordium, as well as throughout the tissues of the rare dead bud encountered, but progressive stages of infection were not observed.

Field studies to measure the occurrence and significance of bud mortality were carried out in late May and early June. A total of 21 trees was felled of which 4 were outside, 8 on the edge of, and 9 inside the area of heavy infestation at Babine Lake. From each tree four 18-inch branch tips were collected at cardinal directions in the upper, mid, and lower crowns. For each sample the total linear lengths of branchlets were measured in inches and the buds were tallied on the basis of the number per 50 linear inches. Normal, necrotic, and budworm-mined buds were tallied separately.

Buds classed as necrotic included all those which failed to flush, and died without any evidence of insect damage. The cause of such bud necrosis could not be positively determined. Although they showed clear evidence of fungus invasion in histological and cultural studies, this could have taken place following death from physiological causes.

The results of the bud sampling demonstrated that there was no difference in the incidence of bud necrosis between infested and non-infested stands. Exclusive of the lower crown sample, which showed a high incidence of necrotic buds in all areas sampled, necrotic buds averaged 8 per cent of the total bud production of the current year in non-infested stands and 6 per cent in heavily infested stands. The total production of buds of the current year was similar in all areas despite virtually 100 per cent destruction of living buds in areas of heavy infestation in the last two years by budworm mining and feeding.

The very high incidence of necrotic buds in the lower crown, which averaged 65 per cent of buds of the current year and ranged from 25 to 100 per cent, was attributed to the weakening of lower branches as a normal fore-

runner to natural pruning. The original report of excessive bud mortality from non-insect causes was based on lower crown samples obtained with pole pruners.

Discussion and Conclusions

The results of this investigation suggested a very marked increase in the population level of the fungus *Pullularia pullulans* in areas of moderate to severe spruce budworm infestation at Babine Lake, British Columbia. The pathogenic capabilities of the fungus were not clearly defined but previous investigations by Molnar (4) have indicated the fungus to be pathogenic under certain conditions. Other investigators have found the fungus associated with forest disease, commonly related to insect activity, and considered it capable of pathogenic activity (1, 2, 3). It has been most commonly reported as a saprophyte, however, and judging by its very wide distribution and infrequent association with disease, it is probably at most a weak facultative parasite.

The importance of the results of this investigation, however, does not rest with the pathological significance of *Pullularia pullulans,* but rather with the fact that the environmental changes brought about by the spruce budworm infestation conditioned such a marked build-up in the fungus population. The results of this study illustrate one example of a major habitat change under the influence of which ordinarily innocuous parasites may attain population levels where they could, in the presence of susceptible hosts, become significantly destructive. The susceptible hosts in this case were trees badly weakened by defoliation.

The reasons for the epiphytotic population level of *P. pullulans* were explained in part by the results of cultural isolations from budworm frass which showed this substrate to be an excellent growth medium for the fungus. The large volume of dead and weakened twigs and branches in the areas of heavy infestation may also have favored a build-up of the fungus. Dead twigs and branches within heavily infested stands ranged from 25 to 50 per cent of the total number of branches within the live crown zone, but only reached 15 per cent in budworm-free and lightly-infested stands. Such dead twigs and branches provide a very favorable growth medium for many weak fungus parasites.

It should be emphasized that *P. pullulans* played an important role in this study mainly because the cultural and sampling techniques used were directed toward determining the importance of bud necrosis. This fungus, however, may well serve as an index of the general increase in the fungus flora of affected stands. A similar build-up of this or other fungi might have been brought to light if sampling and cultural techniques had been directed toward an assessment of twig and branch mortality or some other damage. For example, observations during this study on dead branches indicated the build-up of another fungus, *Retinocyclus abietis* (Crouan) Groves & Wells, which occurred rarely in non-infested stands but was very commonly associated with cankers on dead and weakened branches in areas of heavy infestation and attendant severe branch mortality. The increased populations of fungi and secondary insects to epiphytotic levels as a result of a major biological or edaphic upset may be expected to revert to their endemic population levels rather slowly, and damage may continue for some years after the cause of the original disturbance ceases

to operate. Relevant to this point are recent studies by Thomas (5) in which it was observed that tree mortality continued for some years following the collapse of severe spruce budworm infestations in the Lake Nipigon region of Ontario. In this case continued tree mortality was attributed largely to the activity of bark beetles; pathological influences were not studied, however, and may have also played a part.

The results of bud tallies indicated no increase in the incidence of bud necrosis on trees within the areas of spruce budworm infestation over that found in budworm-free stands. Trees both inside and outside the infestation had a high complement of necrotic buds in the lower crown, but this condition was considered to be consistent with branch weakening preceding natural pruning. The earlier reports of severe non-insect-caused bud mortality in infestation areas was based on lower-crown sampling with pole pruners, which gave a biased result. It is probable that the 6 to 8 per cent of the buds which failed to flush in the mid and upper crowns, whether they resulted from pathological or physiological causes, are not significantly damaging to the trees. It is possible, however, that the excessive twig and branch mortality found in the heavy infestation areas resulted from terminal infection of badly weakened branches by *Pullularia* or other fungi.

ACKNOWLEDGEMENTS

The authors wish to express their appreciation to G. Van Tine and T. Ridler, British Columbia Forest Service, who made the monthly collections for this study, and to Mr. Percy Young, District Forester at Prince Rupert, through whose co-operation the collection schedule was arranged.

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