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EARLY REPORT OF AN INTERGRADING TREE BETWEEN ALPINE AND BALSAM FIR IN NORTH-CENTRAL ALBERTA

Project MS-507

by
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WINNIPEG, MANITOBA
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INTRODUCTION

Balsam fir (*Abies balsamea* (L) Mill.) is a widely distributed species in Canada and ranges from the eastern coast to the northeastern border of British Columbia. In north-central Alberta, balsam fir comes into contact with alpine fir, which extends from British Columbia into Alberta. No other overlapping area with true firs can be found in Canada. Balsam fir grows under a variety of climatic, edaphic, and biotic conditions. The above may suggest reasons for emergence of intermediate trees, and genotypic variations can be expected. One of the most distinct varieties is considered to be the bracted balsam fir (*A. balsamea* var. *phanerolepis* Fern.) which ranges from Newfoundland and Labrador to Ontario and extends into the eastern United States as far south as northwestern Virginia. Little (1953) suggests that the trees in West Virginia may be intermediate between *Abies balsamea* and *A. fraseri* (Pursh). Zavarin (1966), on the basis of chemotaxonomical analyses, states that balsam fir splits into a western form with no 3-carene and an eastern form with some 3-carene. Moss (1953) reported balsam fir and alpine fir (*A. lasiocarpa* (Hook) Nutt.) occurrences south of Lesser Slave Lake, Alberta, and proposed that further attention should be given to the ranges of the two species of *Abies* in Alberta and to the question of intergrading of these species.

In 1959 the author began a project to determine the extent of the variations in alpine fir with respect to several histological and morphological characteristics (Roller, 1966a). To follow Moss' (1953) consideration in finding intermediates between alpine and balsam fir, the field exploration was extended to north-central Alberta where some fir specimens were discovered, which exhibited deviations from the alpine fir characteristics in their needle anatomy and bark and cone morphology. These specimens were supposed to be natural hybrids between alpine and balsam fir (Roller, 1966a).

In 1965 the area located west from the town of Slave Lake on the shore of Lesser Slave Lake was explored again and specimens were collected from the same trees as previously (Roller, 1966a). In the following months a comparative analysis was undertaken between an identified alpine fir tree from Lake Louise, Alberta, an identified balsam fir tree from the Riding Mountain Experimental area, Manitoba, and a putative hybrid tree between alpine fir and balsam fir from the Lesser Slave Lake area.

The main purposes of this preliminary research were to determine the histological and morphological characteristics of the needles and to identify some distinct phenotypical characteristics parallel to the variability of hydrocarbon content in the balsam of the trees.

Because all possible traits in the morphology of alpine and balsam fir are not attainable, the problem becomes a matter of arbitrary selection based on the different traits obtained during the period of field and laboratory examination. A systematic collection throughout the north-central area of Alberta is underway to obtain more specimens and data from the trees selected.

MATERIALS AND METHODS

Specimens were collected in the summer of 1965.

It was considered that alpine and balsam fir specimens, besides the above-mentioned selected tree at the town of Slave Lake, should be collected in some specific areas behind the range limits of the two species where they grow isolated from each other without any possibility of cross fertilization. For alpine fir, such an area (the nearest to Winnipeg) is in the surroundings of Lake Louise in the Rocky Mountains, Alberta, which is located about 250 miles south from the closest scattered balsam fir trees at Whitecourt and in the Athabasca River basin. Balsam fir samples were taken from Riding Mountain, Manitoba, about 1000 miles east from Lesser Slave Lake.

Approximately one 60-year-old tree was sampled from each area because only one of the hybrid trees was selected for testing. Needles were collected from 3-year-old shoots of branches on the north side of the trees and at a height of 150 centimeters. FAA preservative was used for fixing and storing materials in vials. Branches were collected from the same part of the tree as the needles to determine the pubescence of the young shoots. The number and lengths of the lenticels were counted and measured on the bark at the four sides of the trunk.

Resin was taken from the blisters located on the bark. The upper part of the blister was perforated and skived with a sharp knife and pressure was applied just under the rift with the lip of the collecting vessels, so that the balsam flowed directly into the vial. Six ml. of resin were collected from each tree and a few crystals of pyrogallol (antioxidant) were added to the vials as a preservative. The balsam analysis by gas chromatograph was provided in the Forest Products Laboratory of the University of California, Richmond, California.

Twenty needles were selected at random from each vial to measure the length and width of the needle, to count the stomata number and to prepare microslides for histological investigation. Technique used to prepare microslides was adopted from Johansen (1949).

An index system was used to determine the exact position of resin canals in a needle cross-section which was adopted from Roller (1966b).

Besides the traits presented in Table 1 the following characteristics were measured:

Number of rows of stomata on both surfaces of the needle;
Number of stomata in one millimeter of row line on both surfaces of the needle;
Thickness of cuticle;
Number and location of hypoderm layers under the epidermis;
Arrangement of palisade cells;
Ratio of vascular bundle area to the needle cross-section area;
Ratio of tracheids to parenchyma cells in the vascular bundle of the needle;
Position of the vascular bundles as columns of the xylem and phloem cells;
Needle length and width;
Form of needle apex.

Significant differences in characteristics among the three trees were determined by the "t" test.

RESULTS

Only the traits presented in Table 1 exhibit significant differences between alpine fir and balsam fir and show the intermediate characteristics.

A well-known distinct feature between alpine and balsam fir is the high stomata density on the upper surface of the alpine fir needle compared with the low number of stomata on the balsam fir needle. Resin canals in the needle mesophyl of alpine fir are more medial than those of balsam fir. Also the columns and size of vascular bundle elements in the needle cross-section and the density and length of lenticels on the bark help to distinguish the two standard species. However, all the above characteristics show intermediate values for the "hybrid" tree at Lesser Slave Lake and these intermediate values prove the variability of the morphological characteristics.

The author used the chemotaxonomy as an aid to distinguish the chemical nature of the three trees. Chemotaxonomy has been used by several authors (Mirov, 1961, Zavarin, 1965) to examine systematics and evolutionary problems of various conifers. This method is based on the analysis of the balsam for its volatile constituents by gas/liquid chromatography.

Zavarin (1965) analysed the terpene hydrocarbons from balsam of various Abies and demonstrated a higher terpene per cent in the balsam fir than in the alpine fir.

Hydrocarbons of balsam fir from Manitoba (Table 1) show a close relationship to those of balsam firs from different areas of Canada while hydrocarbons of alpine fir from Lake Louise differed considerably from those of alpine fir from different areas in British Columbia (Table 2).

The hydrocarbons of the putative hybrid tree reveal closer relation to the alpine fir than to the balsam fir and it may indicate a stronger effect of the alpine fir parent (assuming it is a hybrid) in the physiology of this offspring. If the well known theory of mother effect would be applied to determine the hybrid feature, it would be easy to conclude that an alpine fir was cross-pollinated by a balsam fir. However, the pheno-typical characteristics of the intergrading tree resemble the balsam fir more than the alpine fir. Furthermore the mixed stand in which the intermediate tree was located contained no alpine fir, while both balsam fir and balsam fir-like intermediates were present. The presence of these intermediates which resemble the selected one indicates that the balsam fir-like trees are the offspring of one or more seed bearer trees of balsam firs which established themselves this area and some of their female strobili were fertilized with alpine fir pollen. It seems obvious that some alpine fir pollen was carried by the south wind from the nearest alpine fir population located in the Swan Hills area, about 30 miles south from the balsam fir stand investigated. An alternative that alpine fir seeds were transported by wind up to the Lesser Slave Lake area from south does not appear to be reasonable because first: it is doubtful that seeds can be supported for a long distance such as 30 miles; secondly: in the fall the north wind is usually blowing at the time of seed ripening.

The above consideration gives opportunity to discuss the genetic constitution of the tree investigated at Lesser Slave Lake. No strong evidence has been found to confirm the presence of alpine fir trees in the near vicinity of the intermediate-like trees. Therefore the question may be raised whether this tree is a hybrid between alpine fir and balsam fir or a genotypical variation of balsam fir only.

All the traits tested for the tree considered exhibit intermediate characteristics between alpine fir and balsam fir but to draw a complete conclusion more field and laboratory research is needed.

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Table 1. Discernible traits of the tested trees.

Species: Elevation Ft.	Location	Lat. °	Long. °	No. stomata in 1mm strip cross needle axis: Ab	No. stomata in 1mm strip cross needle axis: Ad	Resin canal index -	Resin canal ϕ mm	No. rows stomata: Ad	Hydrocarbon of balsam (%): β-pinene	Hydrocarbon of balsam (%): β-phellandrene	Hydrocarbon of balsam (%): limonene	Hydrocarbon of balsam (%): Δ^3 carene	Vas. bundle of needle: Column No.	Vas. bundle of needle: Vertical row no. of - xylem	Vas. bundle of needle: Vertical row no. of - phloem	Lenticel on bark: No. in 16 sq. inch	Lenticel on bark: Length cm	Lenticel on bark: Visibility
Balsam fir																		
800	Riding Mt.	50.5	100.4	98	8	23/5	14	1	47.4	10.6	31.2	-	8.6	3.8	6.7	80	0.5	Barely
Intermediate																		
1800	L. Slave L.	55.3	115.0	98	13	39/10	14	1.7	30.5	24.5	19.5	13.0	5.5	5.8	7.2	15	15<	Visible
Alpine fir																		
5680	L. Louise	51.3	116.3	79	20	45-12	19	3.0	16.0	38.0	26.6	10.0	9.0	5.3	5.8	26	<15	Well visible

Legend: Ab - abaxial side of needle
Ad - adaxial side of needle

Table 2. Analysis of terpen hydrocarbons from balsams of alpine and balsam fir.

(adopted from Zavarin, 1965)

	α-pinene	Camphene	β-pinene	Δ^3 carene	Limonene	β-phellandrene
			%			
Abies lasiocarpa var. lasiocarpa	9.0	0.5	28.0	5.0	2.0	54.5
Abies balsamea	8.0	tr	37.0	tr	39.0	16.0

Legend: tr = trace