Maße. In der Kombination *Pinus sylvestris* X *P. nigra var. pallasiana* konnten nur mit natürlichem Pollen Vollkörner erzielt werden.

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Introgressive Hybridization in the West Himalayan Silver Firs

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Introduction

Silver fir *(Abies* MILLER) is the most widespread conifer in the western Himalayas, especially in the higher ranges. Altitudinally it appears at 2,150 m and ascends upto 3,900 m; thus having an elevational range of about 1,800 m. No other conifer in the Himalayas has such a wide elevational range.

Foresters dealing with the Himalayan firs have long been intrigued regarding the number of species occurring in the western Himalayas (GAMBLE, 1902; BRANDIS, 1906; TROUP, 1921; PARKER, 1940). The problem has recently been resolved by JAIN (1975) who made an extensive survey of the *Abies* populations in various parts of the western Himalayas and studied the morphological and anatomical characteristics of the different taxa encountered. He observed that two species of *Abies* occur in the western Himalayas, separated by altitude, and that a putative hybrid population is found between them. The high altitude sgecies is *A. spectabilis* (D. DON.) SPACH. and the low altitude one is *A. pindrow* ROYLE. In order to reveal the true nature of the hybrid populations the author attempted sampling a transect from the lower species, through several altitudes in the hybrid zone, to the upper species. A statistical analysis of this transect sampling has been presented in the present article.

Materials and Methods

To reveal the hybrids and the extent of influence of the parents in the expression of the phenotypes of the hybrids, ANDERSON's (1949) method of "hybrid-index" was adopted for analysis. Fifteen characters were selected. The data in rcspect of these characters were collected from the Kalpa range in Himachal Pradesh (approximately 31.5° N. lat., 78° E. long.). This site was chosen because both species together with their putative hybrids are found in this area along an elevational range between 2,400 m and 3,900 m. Random samples were collected along the transect between 2,600 m and 3,900 m and consisted of from 40 to 50 mature trees between every 300 m interval along the transect. Measurements were made for the quantitative characters; whereas qualitative characters, which could not be measured, were recorded in relative terms *(Table* 1).

In the present investigation the index is based on scoring

Table 1. — Determination of Hybrid Index

Characters	Class-0	Class-1	Class-2	Class-3	Class-4
Tree height:					
15—50 m	15—22	22—29	29—36	36—43	43—50
Branch angle:					
45°—135°	45—63	63—81	81—99	99—117	117—135
Annual shoot extension:					
3—13 cm	3—5	5—7	7—9	9—11	11—13
Leaf length:					
1—10 cm	1—2.8	2.8—4.6	4.6—6.4	6.4—8.2	8.2—10
Resin canals:					
marginal-4 canals-median	1	—	3	—	5
Stomatal position:					
amphistomatal-adaxial stomata few-hypostomatal	0	—	1	—	2
Young shoot colour:					
pinkish-greyish	0	—	1	—	2
Young shoots pubescence:					
present-scanty-absent	0	—	1	—	2
Female cone length:					
8—15 cm	8—9.4	9.4—10.8	10.8—12.20	12.20—13.6	13.6—15
Ovuliferous scale length:					
2—2.5 cm	2—2.1	2.1—2.2	2.2—2.3	2.3—2.4	2.4—2.5
Ovuliferous scale breadth:					
2.5—3.5 cm	2.5—2.7	2.7—2.9	2.9—3.1	3.1—3.3	3.3—3.5
Seed length:					
7—12 mm	7—8	8—9	9—10	10—11	11—12
Seed breadth:					
4—9 mm	4—5	5—6	6—7	7—8	8—9
Seed wing length:					
8—18 mm	8—10	10—12	12—14	14—16	16—18
Seed wing breadth:					
6—16 mm	6—8	8—10	10—12	12—14	14—16
Total Score:	15 × 0 0	15 × 1 15	15 × 2 30	15 × 3 45	15 × 4 60

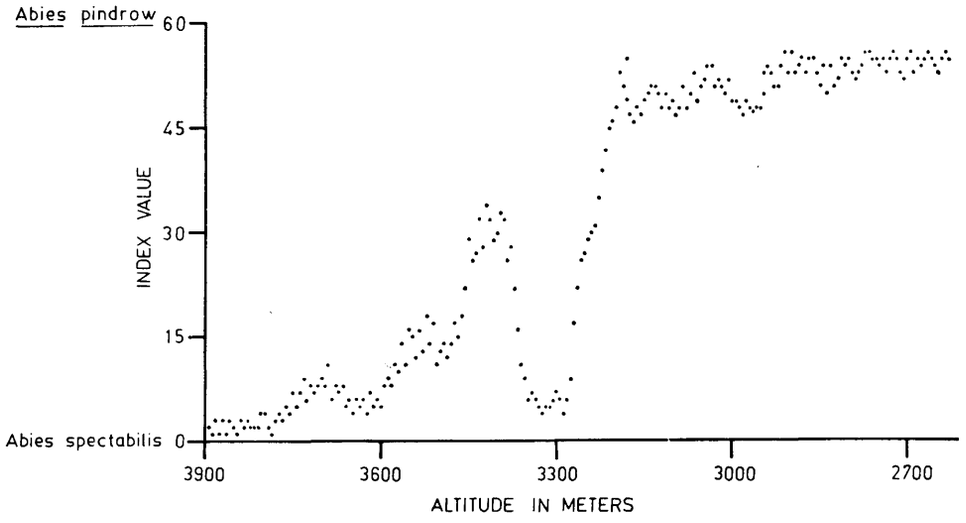

Figure 1. — Hybrid-Index, *Abies spectabilis* (D. Don.) Spach.: *Abies pindrow* Royle.

each of the fifteen characters in five classes. Minimum values for *A. spectabilis* and maximum ones for *A. pindrow* were determined. The distance between the two was divided into five equal classes (0 to 4) having equal class intervals. Individual trees were scored for all the class numbers. Total hybrid-index values for all the individuals thus calculated are plotted against altitude in *Figure 1.*

Discussion

The analysis revealed an array of hybrid-indices with values ranging from 1 to 56. The frequency distribution of these hybrid indices shows a gradual rise of index value with decreasing altitude between 3,900 m and 3,420 m and, again, between 3,170 m and 2,600 m *(Fig. 1).* This indicates introgression or the infiltration of the germ plasm of the one species into the other. Thus the F_1 progenies which might have been produced in the remote past have recurrently backcrossed to their parents and produced introgressants. *A.pindrow var. brevifolia* as designated by Dallimore & Jackson (1966) seems to be an introgressant between

the two species since it has inherited in its shoots the pink colour of *A. spectabilis* and the glabrous character of *A. pindrow*. The segment responsible for pubescence seems to have been removed during the process of segregation. Further, the distribution frequency of the index values shows a strong bimodality between 3,420 m and 3,180 m elevational range and weak bimodalities between 3,690—3,520 m and 3,040—2,900 m. The bimodal distributions show the heterogenous nature of these populations. The strong bimodality at 3,420 m and 3,180 m indicates accumulation of the germ plasm of both the species in this zone. This is evidenced by the presence of a number of trees in this zone which are either pure *A. spectabilis* or *A. pindrow*. It is further of interest that many trees around this zone possess four resin canals in their needles, one median pair (character of *A. pindrow)* and another marginal pair (character of *A. spectabilis).* These trees probably belong to the F_1 generation produced comparatively recently by crossing between the two pure species in this zone. When these individuals backcross to one of their parent species, the co-dominance of the other species in respect to position of the resin canals is removed and the progeny possesses only a single pair of resin canals, the position of which corresponds to the parent species involved in backcrossing. Thus through segregations a mosaic population is created which has been subjected to selection pressure at different altitudinal zones. The successive populations are sympatric at the interfaces and there is no barrier to interbreeding.

Summary

There are two distinct species of *Abies* in the western Himalayas, a high altitude one *A. spectabilis* and a low altitude one *A. pindrow;* which hybridize freely forming intermediate populations in the middle zones. Analysis of morphological data from individuals along a sample transect through several altitudes, using ANDERSON's method of hybrid-index, revealed introgression. The frequency distribution of the hybrid-index scores showed a strong bimodality in the middle of the distributional range (between 3,420—3,180 m) and indicates the accumulation of the germ plasm of both the species in this zone.

Key words: West Himalayan silver firs, Introgressive hybridization, *Abies pindrow, Abies spectabilis,* hybrid index.

Zusammenfassung

Im westlichen Himalaja kommen in Lagen zwischen etwa 2000 und 4000 m vornehmlich zwei Tannenarten vor, in hohen Lagen *Abies spectabilis* (D. DON) SPACH und in tieferen Lagen *Abies pindrow* ROYLE. Die Untersuchung von 15 morphologischen Merkmalen, die stichprobenhaft im Überlappungsgebiet beider Arten erfaßt wurden, läßt auf introgressive Hybridisation schließen.

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Studies of variation in Central American Pines
I. The identity of Pinus oocarpa var. ochoterenai Martinez

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General Background

International provenance trials organized by the Unit of Tropical Silviculture at the Commonwealth Forestry Institute, Oxford, using *Pinus oocarpa* SCHIEDE as a principal species, were started in 1971 (KEMP, 1973 a, b; F.A.O., 1974). The trials at present involve comparative experiments in nearly 40 tropical countries and are based chiefly on seed collections made from carefully selected populations in the southern parts of the natural range of the species in Central America. Previous to the Oxford trials, most of the seed of this species used in earlier silvicultural studies had been obtained from Mexico. Such early introductions were often of unknown provenance and sometimes incorrectly named.

As an adjunct to the trials, a botanical study of *P. oocarpa* has also been started in order to ascertain its variation over the whole of its natural range and to investigate the taxonomic status of the several infra-specific taxa which have been described in the past. The status of those species which are considered doubtfully distinct from it will be examined, as well as the possibility of its hybridization. Since all seed sources of the different provenances issued from Oxford are fully documented and supported by correlated herbarium material and sometimes timber and resin samples, the two aspects of the work taken together will form the basis of a comparative experiment or extensive gene-ecological study of the type carried out by CLAUSEN, KECK and HIESEY (1940) in California using herbaceous plants. Botanical specimens from trees raised in the provenance trial plots throughout the tropics are being collected in order to see how the species behaves and varies in completely new environments outside its area of natural distribution.

In this first paper the identity of the Mexican *Pinus oocarpa* var. *ochoterenai* MARTÍNEZ is discussed, a taxon whose name and identity are already giving rise to a number of problems in the provenance work involving the species.

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