chen-Austriebs abhängig zu sein. Der Ölgehalt der Nadeln und Triebe spielt dabei offenbar eine Rolle.

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Screening of Haploxylon Pines for Resistance to the White Pine Weevil

I. Pinus peuce and P. strobus grafted on Scots pine[1])

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To be fully acceptable for planting in eastern North America, white pine, Pinus strobus L., should be resistant to the blister rust, Cronartium ribicola FISCHER, and the white pine weevil, Pissodes strobi PECK. In this regard, several exotic white pine species easily crossable with native white pine are of interest. Among these, Pinus peuce GRISEB. carries a considerable degree of resistance to blister rust, is hardy in central Ontario, and grafts show more weevil resistance than P. strobus at Maple, Ontario. Therefore, a cooperative research project was initiated in 1958 with the Great Lakes Forest Research Centre, Sault Ste. Marie, Ontario, to study the weevil resistance of selected P. strobus and P. peuce field-grafted on Scots pine, P. sylvestris L., in a small plantation subjected to weevil attack in Kirkwood Township, Ontario. This paper reports the results of the study. In 1961, further field-grafting of several white pine species and hybrids on P. strobus was initiated and the results will be presented in the second paper of this series.

Materials and Methods

In spring, 1947, Scots pine to be used for grafting were planted in ploughed furrows oriented north-south and spaced 6 X 6 feet. Scots pine is suitable for rootstock because of its adaptability to varied sites, its immunity to blister rust, and its rapid growth. Scions of P. peuce and P. strobus, collected from trees of known reaction to weevil attack, were top-grafted on the Scots pine during the spring of 1957. The field-grafting technique used has been previously determined for P. strobus (HEIMBURGER, 1948). Scions from the following sources were used:

1) Ten P. peuce from single-row windbreaks along Highway Nr. 7, east of Havelock, Ontario, containing admixtures of red pine, P. resinosa AIT., and mugho pine, P. mugo TURRA, adjacent to numerous open-growing, heavily weeviled P. strobus and growing in shallow sandy soil over limestone. The degree of weevil attack on P. peuce ranged widely. The selected trees, mostly dominants about 10 feet tall, represented two reaction types contrasting in apparent resistance to weevil attack.
2) Five unweeviled P. strobus plus trees representing the slender-leader type of white pine, selected in plantation 20a, Provincial Forest Nursery Station, Midhurst, Ontario. The plantation was established in 1924 on fine sandy soil and contains trees of above-average growth form and low incidence of weevil attack.
3) Five thick-leader type P. strobus, with heavier than average weevil attack, growing immediately north of the grafted Scots pine. The young trees are open-growing, coarse-branched with poor growth form, and represent the natural old-field white pine growing in mixture with scattered aspen (Populus tremuloides MICHX.), white birch (Betula papyrifera MARSH.), and pin cherry (Prunus pennsylvanica L.), characteristic of the area.

Scion sources representing the two contrasting reaction types to weevil attack will hereafter be designated resistant and susceptible, respectively. The grafts consisted of 20 scions each of five clones of the resistant and susceptible

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P. peuce and *P. strobus,* making a total of 400 scions. In every second row, 40 suitable Scots pine were grafted alternately with two scions of *P. peuce* or two scions of *P. strobus*. The sequence was carried out in five rows, each grafted row containing four clones, one of each species and reaction type.

In June 1957, three months after grafting and again in August, the grafts were examined for survival. Then the protective bags were removed and the stock plants were top-pruned to decrease competition with the grafts. In the fall of 1959 the ungrafted rows of Scots pine were removed. In July 1962, the grafts were reduced to one per stock plant, the latter being heavily pruned, and all ungrafted Scots pine in the rows were removed.

Each fall from 1958 to 1963 inclusive, the grafts were examined for leader vigour and reaction to weevil attack. Leader vigour was classified by length and diameter. Chi-square tests with YATES adjustment for continuity were made in all comparisons of the two species.

In this study weevil resistance of white pine is subdivided into,

1) a series of non-preference responses by the weevil elicited by the white pine (PAINTER, 1951), expressed by the proportion of available leaders attacked (frequency of attack) and called resistance to weevil attack, and
2) a series of recovery responses of the white pine to weevil attack (KULMAN and HARMAN, 1965) and expressed by the proportion of attacked leaders killed or recovered from weevil attack.

Thus, weevil resistance is the combined effect of resistance to attack and recovery from attack and is expressed by the proportion of available leaders killed or recovered from attack.

Results and Discussion

Surveys of grafting compatibility during the first year showed that *P. strobus* had a significantly lower survival than *P. peuce* grafts *(Table 1)*. This is in accord with the results of field-grafting at Maple, Ontario.

The grafting technique opens some possibility for short-term selection and propagation of weevil-resistant white pines including eventual management of seed orchards. According to MIROV (1945) the oleoresins found in the resin ducts of pines are formed locally in the surrounding living cells and are not transmitted from rootstock to scion by grafting. Thus, if oleoresins are related to weevil resistance (MACALONEY, 1930), their qualitative effects in the scions are not changed by grafting. On the other hand, resin pressure related to weevil resistance (PLANK and GERHOLD, 1965) is, in grafts, influenced by water uptake by the rootstock and passage through the place of grafting. This may differ by species in heteroplastic grafting.

The syndrome of heavy weevil attack on *P. strobus* consists of a heavy residual population of weevils successfully attacking open-growing, vigorous trees with strong (thick and long) leaders, having thick bark with few and small resin canals with poor resin flow, and with poor apical dominance. In addition, some genetic host-parasite relationship between the co-existing white pine weevil populations must be assumed (MODE, 1958; SANTAMOUR, 1965). The parameters of weevil resistance of *P. peuce* are unknown. In this study the grafts of both species were examined for leader vigour, frequency of weevil attack, and leader mortality. The results are analyzed and discussed in relation to weevil resistance.

Table 1. — Grafting compatibility of *P. strobus* and *P. peuce* scions with *P. sylvestris.*

	Living	Dead
P. strobus	99	101
P. peuce	168	32
$\chi^2 = 52.08$	$P < 0.01$	

Table 2. — Number of leaders of the two contrasting reaction types of *P. strobus* and *P. peuce* with good to moderate, and poor vigour.

	P. strobus		*P. peuce*	
	Good-Mod.	Poor	Good-Mod.	Poor
Resistant	63	23	300	52
Susceptible	133	64	152	79
Totals	196	87	452	131

Chi-Square values:
P. strobus: Resistant vs Susceptible; $\chi^2 = 1.20$ n.s
P. peuce: Resistant vs Susceptible; $\chi^2 = 31.34$ $P < 0.01$
Totals: *P. strobus* vs *P. peuce;* $\chi^2 = 6.48$ $P < 0.02$

Leaders examined annually were classified as being of good to moderate, or poor vigour and the numbers in each class of the two contrasting reaction types to weevil attack of *P. strobus* and *P. peuce* are shown in *Table 2,* together with chi-square values of appropriate comparisons. A smaller proportion of *P. strobus* leaders were of good to moderate vigour compared to *P. peuce. P. strobus* leaders classified as resistant and susceptible were not significantly different in apparent vigour, but in *P. peuce* a greater proportion of leaders classified as resistant were of good to moderate vigour.

The number of leaders of the two species and reaction types to weevil attack that were attacked and missed by the weevil are shown in *Table 3.* Differences in frequency of attack were not significant on either *P. strobus* or *P. peuce,* classified as resistant and susceptible. When the species are compared without reference to the two contrasting reaction types, the results show that a smaller proportion of *P. strobus* than *P. peuce* leaders were attacked by the weevil. Thus, the non-preference responses by the weevil elicited by *P. strobus* were more effective than those elicited by *P. peuce.* The factors involved are not clearly understood and the results should be viewed with reference to previous work on weevil attack in *P. strobus.* For example, it has been shown that leaders of small upper diameter (slender leader types) are less frequently attacked than leaders of large upper diameter (SULLIVAN, 1959). In addition, weevil attack has been positively correlated with stem- bark thickness (KRIEBEL, 1954) and slender leaders have relatively thinner bark than stout leaders (SULLIVAN, 1961). The selection for slender leaders could, therefore, be important in breeding for weevil resistance. Selection for long, slender leaders would include the possibility of selection for strong apical dominance and would not be directed against ecological efficiency and growth rate.

On the other hand, under the conditions of low overall frequency of attack found in this investigation (17.1%), an attacked leader could well be considered to be attractive to the weevil, but freedom from attack does not necessarily indicate leader unattractiveness. A low frequency of attack under conditions favouring heavy infestation may be based on heavy resin flow making oviposition in feeding cavities unattractive to the weevil (GERHOLD, 1962; PLANK and GERHOLD, 1965). Unattractiveness has been correlated with morphological characteristics, such as bark thickness, depth of inner and outer resin ducts, and the vertical varia-

Table 3. — Number of leaders of the two contrasting reaction types of *P. strobus* and *P. peuce* attacked and missed by the weevil.

	P. strobus		*P. peuce*	
	Leaders Attacked	Leaders Missed	Leaders Attacked	Leaders Missed
Resistant	4	82	73	279
Susceptible	14	183	58	173
Totals	18	265	131	452

Chi-Square values:
P. strobus: Resistant vs. Susceptible; $\chi^2 = 1.09$ n.s.
P. peuce: Resistant vs. Susceptible; $\chi^2 = 1.79$ n.s.
Totals: *P. strobus* vs. *P. peuce;* $\chi^2 = 35.85$ $P < 0.01$

Table 4. — Number of leaders of the two contrasting reaction types of *P. strobus* and *P. peuce* attacked and killed by the weevil.

	P. strobus		*P. peuce*	
	Leaders Killed	Leaders Not Killed	Leaders Killed	Leaders Not Killed
Resistant	3	1	20	53
Susceptible	8	6	20	38
Totals	11	7	40	91

Chi-Square values:
P. peuce: Resistant vs Susceptible; $\chi^2 = 0.47$ n.s.
Totals: *P. strobus* vs *P. peuce;* $\chi^2 = 5.28$ $P < 0.05$

tion of these in the leader (Stroh, 1964; Stroh and Gerhold, 1965). Possibly, there are other leader characteristics influencing frequency of attack. Nevertheless, the positive correlation of frequency of weevil attack on *P. strobus* with leader vigour as expressed by upper diameter (Sullivan, 1961) should be checked in other *P. strobus* material and in related species for possible use in indirect selection for weevil resistance. The greater frequency of attack on *P. peuce* compared to *P. strobus (Table 3)* may be related to the greater leader vigour of *P. peuce (Table 2).*

Table 4 shows the number of leaders of the two contrasting reaction types of *P. strobus* and *P. peuce* attacked and killed by the weevil, together with appropriate chi-square values. Within the species, leader mortality of the resistant and susceptible *P. strobus* could not be adequately compared because the sample was too small; it was not significantly different in *P. peuce.* Comparison of the totals between species showed that mortality of attacked leaders was greater in *P. strobus* than in *P. peuce.* This is in contrast to the results on frequency of weevil attack *(Table 3).* Thus, the recovery responses of *P. peuce* to weevil attack were greater than in *P. strobus.* Before considering this further, it should be pointed out that a weevil attack may result in the death or loss of apical dominance of the leaders and may not be successful, i. e., produce new weevils (Kulman and Harman, 1965, 1967). In this study, multiple leaders were observed in 1962 and 1963, i. e., the loss in apical dominance in some leaders became apparent in the fifth and sixth year of tally. This occurred in 75 and 81 per cent of the attacked grafts of *P. strobus* and *P. peuce,* respectively, but with no significant difference between the two species. Thus, in *Table 4,* only leaders killed by the weevil are considered, regardless of the success of attack and its influence on apical dominance.

As a consequence of the compensatory action of frequency of attack and leader mortality, an attempt to show a significant difference in weevil resistance between the two species was unsuccessful when expressed through the number of available leaders killed (*P. strobus* — 11 killed, 272 not killed; *P. peuce* — 40 killed, 543 not killed). Nevertheless, the high incidence of recovery following weevil attack in *P. peuce* warrants further consideration. Leader recovery is presumably caused by heavy resin flow resulting in high mortality of weevil larvae after hatching, although resin crystallization by weevil larvae (Santamour, 1965) serves to counteract this in some leaders. Heavy resin flow is presumably influenced by environmental factors, such as hydration and adequate nutrient supply, and by the morphological characteristics discussed earlier. If these are under genetic control, selection for heavy resin flow would not be directed against growth vigour and overall ecological efficiency, nor against strong apical dominance. However, it might be directed towards selection for leader thickness which in pines may be correlated with side-branch thickness, undesirable in the production of high lumber grades and of high-quality pulpwood.

Summary

Equal numbers of grafts were made of *P. strobus* and *P. peuce* on planted Scots pine from ortets selected for freedom from weevil attack and heavy weevil attack, under conditions of heavy weevil infestation. Grafts of *P. peuce* survived better and produced more leaders of good and moderate vigour than grafts of *P. strobus.* Within *P. peuce,* grafts from trees selected for freedom from weevil attack produced more leaders of good and moderate vigour than grafts from heavily attacked trees; within *P. strobus* there was no difference in vigour. The initial sampling of the two contrasting reaction types within each species did not result in significant differences in frequency of weevil attack or leader mortality. When combined for comparison between species, however, more *P. peuce* were attacked but fewer leaders of these were killed than of *P. strobus.* This reversal in significance nullified attempts to show a difference in weevil resistance between the two species. The study opened up possibilities in future breeding programs to select resistant material on the basis of the physical and morphological characteristics of white pine leaders and on resin flow.

Zusammenfassung

Es wurden gleiche Pfropflingsanzahlen von *Pissodes*-freien und *Pissodes*-befallenen *Pinus strobus*- und *P. peuce*-Reisern auf *P. silvestris*-Unterlagen hergestellt. Die *P. peuce*-Pfropflinge überlebten besser als die *P. strobus*-Pfropflinge. Die *P. peuce*-Pfropflinge, deren Reiser auf *Pissodes*-Freiheit ausgelesen worden waren, produzierten mehr und kräftigere Triebe als die, deren Reiser von befallenen Pflanzen stammten. Bei *P. strobus*-Pfropflingen gab es keine Unterschiede. Die anfängliche Auslese auf die 2 Reaktionstypen erbrachte aber keine signifikanten Unterschiede beim späteren Befall der Pfropflinge und deren Triebsterben. Es ließ sich auch kein Unterschied im *Pissodes*-Befall bei beiden Arten zeigen. Für ein zukünftiges Züchtungsprogramm werden Anregungen gegeben.

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Cytogenetical Studies of Himalayan Aceraceae, Hippocastanaceae, Sapindaceae and Staphyleaceae

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Introduction

The forests in the Himalayas vary a great deal in composition. The conifers are of relatively little importance in contrast to the vast representation of hardwood species. Amongst 180 recognised commercial timbers of this region, less than a dozen are softwoods. For any rational programme of the tree improvement on cytogenetical lines, it is pertinent to have prior information on their chromosome number, meiotic behaviour, morphological and cytological variability, if any, geographical or ecological races and flowering and fruiting season. Almost complete lack of such data on species under review promoted the present studies.

Materials and Methods

Material for meiotic studies was collected from wild sources, excepting a few exotics, in the Himalayas. Flower buds were fixed in CARNOY's fluid. Squashing of anthers was accomplished in 1% aceto-carmine. Slides were made permanent in Euparal. Figures are at a uniform magnification of × 1360. Voucher specimens have been deposited in the Herbarium, Panjab University, Department of Botany, Chandigarh-14 (India). The genera and species under each family are arranged in the succeeding pages after HOOKER (1872), but those of forestry importance are dealt with first. Numerical strength of the genera and families is adopted from WILLIS (1966).

Results

The chromosome counts of 30 species belonging to 10 genera and 4 families are given in *Table 1*. Of these, 21 species, a variety and 4 genera are cytologically worked out for the first time. The course of meiosis has been observed to be normal in all taxa. Detailed observations have been given only for a few species of morphological or cytological interest.

ACERACEAE:

The family is comprised of 3 genera primarily of the North temperate hemisphere. *Acer* with 200 species is the largest genus. The maples are famous for their handsome foliage. *A. saccharum* of North America is tapped for sugar. Several species produce timber. GAMBLE (1902) states, "structure of all Maples, Indian included, is very uniform and most of the Indian species possess the handsome silver grain characteristic of Maple wood in general". The genus is not well appreciated in India because of its distribution in the localities of difficult approach in the temperate Himalayas. Fifteen species, besides some exotics inhabit the Himalayas. Of these, *A. thomsoni, A. campbellii, A. osmastoni, A. niveum, A. hookeri, A. pectinatum, A. sikkimense, A. papilio* and *A. stachyphyllum* are restricted to E. Himalayas, *A. caesium* is confined to W. Himalayas and *A. oblongum, A. pictum, A. villosum, A. caudatum* and *A. laevigatum* are met both in the E. and W. Himalayas. Five species *A. oblongum, A. caesium, A. thomsoni, A. campbellii* and *A. pictum* yield timber of commercial value.

A. campbellii is the commonest maple of the Eastern Himalayas, often making Oak-Laurel-Maple association. It has a wide altitudinal range from 1800—3600 m. Tall deciduous tree, 20—40 m. in height and 2—5 m. in girth with a clear straight bole upto 12 m. high.

The species is known for its heterophyllous nature. BANERJI (1958) segregated the species into two varieties, *campbellii* and *serratifolia,* the former with serrulate margin, glabrous nerves and dense inflorescence and the latter showing serrate margin, pubescent nerves and elongate inflorescence. The present field observations in the Darjeeling hills revealed the occurrence of an intermediate type with smaller and less serrated leaves than var. *serratifolia (Fig. A).* It has been observed that the plants possessing 5—7 lobed deeply cut leaves with serrate margin occupy distribution range of 2100—2600 m., intermediate ones with 5 lobed serrulate and dark green leaves occur between 2400—2800 m., while those having 7 lobed conspicously serrate leaves are met with above 2600 m. ascending upto timber line where they become stunted.

At M-I, 13 bivalents are seen *(Fig. 4).* The taxa corresponding to varieties *campbellii* and *serratifolia* show 90% well filled and stainable pollen. The populations with inter-