

Studies in *Populus ciliata* Wall. ex Royle. I. Correlation of phenotypic observation with sex of trees¹⁾

By P. K. KHOSLA²⁾, S. P. DHALL³⁾ and D. K. KHURANA⁴⁾

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Summary

A survey of the sex-ratio in *Populus ciliata* in the Western Himalayas has revealed 3:2 male:female ratio. A multivariate analysis did not show any differences between the male and female trees with respect to height, diameter and specific gravity. On average the better performance of female trees with respect to the characters studied may be attributed to the occurrence of males in competition with dominant species, while the females prefer exposed and open places.

Key words: *Populus ciliata*, sex-ratio, multivariate analysis, height, diameter, specific gravity.

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²⁾, ³⁾ Tree Breeder and Research Fellow, respectively—Department of Forestry, Agricultural Complex, H.P. University, Solan, H.P., India.

⁴⁾ Asstt. Prof. Agric. Statistics, College of Agriculture, H.P. University, Solan, H.P., India.

Zusammenfassung

Systematische Studien im Rahmen der züchterischen Bearbeitung von *Populus ciliata* WALL. ex ROYLE im westlichen Himalaya ergaben bei dieser diözischen Baumart ein Geschlechter-Verhältnis von männlich 3 : weiblich 2. Die weiblichen Bäume dieser Art zeigen eine etwas größere Wachstumsleistung, die jedoch standortbedingt zu sein scheint bzw. aus der Konkurrenz zu anderen Arten resultiert.

Introduction

Himalayan poplar (*Populus ciliata* WALL. ex ROYLE) is a tall, straight, clean-boled, deciduous tree found throughout the Himalayas at altitudes of 1200–3500 m. In the Western Himalayas it is a common and conspicuous tree in mixed broad-leaved, oak and coniferous forests attaining largest dimensions in the ravines. The species is considered useful for afforestation purposes on unstable hill sides (TROUP 1921; ANON. 1969), and also as a potential tree for pulp and paper, the match industry and packing cases.

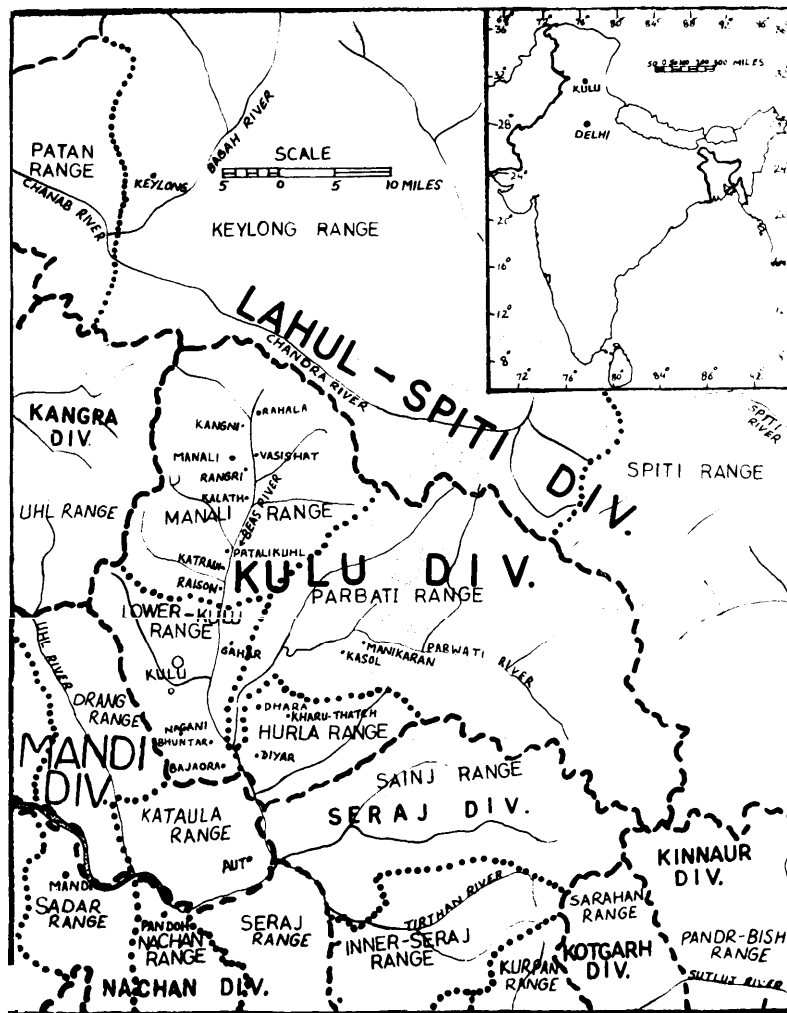


Fig. 1. — Map shows the area surveyed (31° 58' N 77° 6' E).

The species does not form pure forests, therefore it has not attracted much attention from foresters for its intensive exploitation and consequently no improvement programme was initiated in the species. To explore the suitability of this Himalayan poplar for varied uses in the fir-zone and also in the lower elevations, systematic studies on the basic biology of the species with a view to starting a breeding programme were initiated in 1976. Here, we present data on sex-ratio and sex-related characteristics of male and female trees from the natural stands of *P. ciliata* from the Manali, Kulu, Hurla and Parwati Ranges of the Kulu Forest Division in the Western Himalayas (Fig. 1).

Material, Methods of Collection

The data on the sex-ratio of whole populations of *P. ciliata* in the natural stands were collected in April at a time when the trees flower. Since the species occurs in patches alone, these patches were analysed for sex-ratio. In each stand the most dominant tree was selected and within a radius of 20 m ten dominant and co-dominant trees were analysed for height, diameter, etc. comprising five male and five female trees. Keeping in view that a minimum of two observations are required for the estimation of error and also this being a preliminary/pilot study wood specific gravity was analysed for only two male and two female trees in each patch. Here, 11 mm in diameter core samples were taken from the eastern side of the tree growing in the open area and from the inner side of the tree growing on a slope. The specific gravity was deter-

mined by the water displacement method at 15% moisture content.

Results and Discussion

The current survey involving 2531 trees in the North-West Himalayas showed that there were 1562 or 61.71% males to 969 or 38.28% females, thereby, giving an overall 3:2 male/female ratio. The sex-ratio for each locality is given in Table 1. The significance of population proportion $p = 0.61$ is tested using Student's *t*-test at 24 degrees of freedom and 1% level of significance. This gave a highly significant difference. Therefore, the Null Hypothesis that the $p = 0.5$ is rejected i.e., the proportion of males to females in general is not 1:1. For further analysis of the sex-ratio, we calculated the 95% confidence limits. (Here, it is safely assumed that p is distributed according to the normal distribution, and all p 's from different places have the same distribution.) The 95% confidence limit for p is 0.16 ± 0.04 . (Table 1.)

The deviation from 1:1 ratio in the current analysis differs from the previous investigations in the species and hybrids of poplars carried out by EINSPAHR (1962), FARMER (1964), LANGHAMMER (1963), MUHLE LARSEN (1970), REIM (1930) and WALTERS and BRÜCKMANN (1965); but insignificant preponderance of males have always been found in their samples. However, PAULEY and MENNEL (1957) also reported deviation in sex-ratio in *P. tremuloides* with 3males:1-female.

The data on the average height, diameter (D.B.H.) and specific gravity in relation to male and female trees are given in Table 2. The average height of the male trees was found to be 25.76 m and of female trees 26.01 m. The average diameter of the trees varied from 33.02 to 48.25 cms in males, from 37.52 to 52.61 cms in females, while specific gravity varied from 0.39 to 0.47 in males and 0.39 to 0.53 in females. The average age of the trees varied from 22 to 27 years. There may be slight differences in age because of being determined through core samples. But being the dominant and co-dominant trees in a population they were presumed to be even aged. In case of old trees which were more than 50 years old the height differences are not much, as after reaching a particular height the trees do not add length but expand in diameter. This is evident from the comparison of diameter of the old trees to the young mature trees of the Gahar regions (see Table 2).

Analysis of variance for height, D.B.H. and specific gravity for different places was performed separately, where no significant differences were observed among as well as within places under study. The same ten places from the Kulu Forest Division were taken as replicates for multivariate analysis.

The classical D^2 -Statistics developed by Mahalanobis (BRYANT 1966) was used for testing the significance of differences between mean vectors of three characters analyzed viz: height of the tree, D.B.H. and specific gravity of the male and female populations.

Here:

$$D^2 = (\bar{X}^{(1)} - \bar{X}^{(2)})' \left(\frac{s}{n_1 + n_2 - 2} \right)^{-1} (\bar{X}^{(1)} - \bar{X}^{(2)})$$

Where $(\bar{X}^{(1)} - \bar{X}^{(2)})'$ is a column vector and $(\bar{X}^{(1)} - \bar{X}^{(2)})$ is a row vector and n_1 and n_2 represent number of observations in the male and female populations respectively. s is a combined matrix of corrected sum of squares and cross products.

Table 1. — Sex-ration of *Populus ciliata* in the Kulu Forest Division (31° 58' N 77° 6' E).

Locality	Total No. of trees (in patches)	No. of male trees	No. of female trees
<i>Lower Kulu Range:</i>			
1. Mati-kochar (Gahar)	23	13	10
2. Nagani Forest	178	93	85
3. Raison to Katrain	57	33	24
4. Katrain to Patali-kuhl	96	59	37
5. Patali-kuhl (Central Bihal)	81	59	22
<i>Manali Range:</i>			
6. Patali-kuhl Bihal (right side)	60	50	10
7. Patali-kuhl Bihal (left side)	135	102	33
8. Pangan Khaner to Kalath	34	17	17
9. Karain Bihal	208	161	47
10. Rangri Khaner to Bhanu Khaner	61	48	13
11. Aleo Bihal	101	55	46
12. Manali to Chachoga	15	9	6
13. Manali to Chadhiari	91	54	37
14. Vasishat Bihal	83	49	34
15. Bhang Bihal	26	20	6
16. Rahla	21	11	10
17. Dhundi to Solang	13	6	7
18. Kangni Forest	341	219	122
19. Goshal to Manali	339	192	147
20. Manali to Rangri	159	69	90
21. Rangri to Kalath	150	80	70
22. Manali to Manalghar	28	15	13
<i>Hurla Range:</i>			
23. Masu Dimbkari (Diyar)	67	33	34
24. Kharu Thatch	108	76	32
<i>Parwati Range:</i>			
25. Manikaran Bihal	56	39	17
TOTAL	2531	1562	969

$N = 25$; Male proportion (p) = 0.61; Female proportion (q) = 0.39; S.D. of proportion = 0.11.

Table 2. — Relationship of sex to height, diameter and specific gravity in the trees of *Populus ciliata*
WALL. ex ROYLE.

Locality	Male			Female		
	Height (m)	D.B.H. (cm)	Sp. Gr.	Height (m)	D.B.H. (cm)	Sp. Gr.
Katrain	23.36	48.25	0.39	28.16	46.42	0.45
Patali-kuhl (central bihal)	19.62	35.60	0.39	20.29	42.47	0.46
Kalath	25.90	47.01	0.43	27.31	37.75	0.43
Rangri	21.08	38.63	0.44	20.96	38.18	0.39
Gahar	34.44	42.05	0.43	32.55	62.73	0.53
Vasishat	24.12	41.52	0.47	26.51	42.13	0.44
Kharu Thatch	29.91	38.71	0.41	29.68	42.57	0.44
Nagani	26.21	46.18	0.42	26.33	46.52	0.50
Kangni	27.61	36.72	0.42	24.87	39.14	0.40
Manikaran	23.65	39.64	0.46	24.08	52.64	0.51
Mean	25.59	41.43	0.43	26.07	45.05	0.46
Old mature trees	33.25	127.63	0.41	36.84	140.60	0.37

In our case the value of D^2 was found to be 0.55. The hypothesis of equality of mean vectors was tested by the quantity:

$$Q = \frac{n_1 \times n_2}{n_1 + n_2} \frac{(n_1 + n_2 - p - 1)}{p} \frac{D^2}{n_1 + n_2 - 2}$$

(Where $p = 3$, denoting trivariate population) which is distributed as SNEDECOR'S F with p and $(n_1 + n_2 - p - 1)$ degrees of freedom.

Our analysis showed $Q = 0.82$ which is much less than the tabulated value 3.24 of F at 5% level and (3,16) degrees of freedom. Hence, the hypothesis of equality of mean vectors may be accepted implying, thereby, that the male and the female trees belong to the same populations as far as the three characters under study are concerned.

This is in contrast to the earlier reports which invariably mention superiority of male in vigour and form (MUHLE LARSEN 1954, PAULEY 1948, 1949, FARMER l.c.), while no significant sex-related differences were observed in vigour and form by EINSPAHR (l.c.), FARMER (l.c.) and WALTERS and BRÜCKMANN (l.c.).

MUHLE LARSEN (1970) based on his studies on family progeny analysis contradicted his earlier statement and attributed this growth-form relationship to the sex of trees to be a genetic character related with superiority of the family. It has also been suggested in the case of Aspen that the male vigour and sex may be influenced by their clonal growth habit (BARNES 1959), which results from the tendency to regenerate vegetatively via root-suckers. On the other hand, BAWA and OPLER (1977) dealing with dioecious tropical trees have stated that differences in the physiology and ecology of the two sexes may lead to differential mortality of staminate and pistillate seeds and/or seedlings dispersed randomly in the heterogeneous environment.

P. ciliata is also propagated clonally by root-suckers but natural regeneration usually takes place by seeds. This aspect alone cannot be attributed to the preponderance of males or females. It was observed that the male trees were growing in competition with *Pinus wallichiana*, *Cedrus deodara* and *Picea smithiana* trees in the forests and with *Alnus* spp. and *Ulmus wallichiana* in the Bihal area (river basin), while the female trees invariably grow in little ex-

posed or open areas. Thus the little better performance of female trees on an average could be attributed to the factor that they had an easy access to the nutrients thereby better growth rate and less in number. On the other hand male trees face a competition for nutrients, hence losing their vigour but more in number. This aspect was established in Kharu Thatch (Hurla Range) where there is a thick mixed forest of *Pinus wallichiana*, *Cedrus deodara* and *Picea smithiana* intermixed with few poplar trees, here female trees occur only in exposed canopy while the males compete with other dominant species for light and nutrients thereby having a narrow crown.

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