CHANGE OVER TIME OF BRANCHING DEFECTS IN CORSICAN BLACK PINE (*PINUS NIGRA* SSP. *LARICIO* VAR. *CORSICANA*) OF CENTRAL FRANCE PROVENANCE

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SUMMARY

Change of branching defects over time was studied in a progeny test of. A sample of 337 trees was measured seven years after their first evaluation (ages 9 and 16). The change in the frequency of forks and ramicorns over time, and the influence of different whorl traits on these changes were studied. The percent of forks and ramicorns that could be recognised at age 16 was only 31.6 p. 100. About 55 p. 100 of ramicorns disappeared, due to the flattening of the branch angle with time. Trees with stable ramicorns were characterised by a narrow initial branch angle, a high level of polycyclism on branches and a large branch diameter.

With time and diameter growth of the stem, the supplementary whorls on polycyclic branches may be progressively inserted in the stem before natural pruning occurs, resulting in a big local defect. Consequences for early selection are discussed.

KEY WORDS: *Pinus nigra*
Branching defects
Early selection

INTRODUCTION

Corsican black pine, *Pinus nigra* Arn. ssp. *laricio* (Poir) Schwarz var. *corsicana* (Loud) Franco, covers 45,000 ha in the island of Corsica (France). In France, this variety has been widely used for afforestation, since it is the third most important species after Douglas Fir and maritime pine. In the central part of France, 22,000-26,000 ha have been recently afforested (Bene, Vasselier, 1989).

By comparison with other black pine varieties, Corsican black pine shows the best stem form and branching habit, and gives the greatest wood production when tested in provenance tests. They present a monocyclic fixed growth pattern, with one clearly defined whorl in each year, a large number of small branches and a large branch angle (Roman-Amat, 1984).

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The black pine of the Central France provenance is an artificial variety originating from afforestation with the corsican provenance in the middle of the XIX century. It has a greater vigour (height and diameter growth) than the natural Corsican provenance, probably because of an effect of natural selection or a breaking of the neighbouring cycles, or both (Roman-Amat, 1984; Portefaix, 1987a). However, this vigour is linked with and increase in branching defects resulting in a decrease in the economic value of the tree. In the Centre provenance, Rabat (1985) and Portefaix (1981, 1987b) reported an increase in the proportion of trees with multiple whorls per year on the stem in the young stage, a smaller number of bigger branches per whorl, a smaller branch angle and the presence of *lammas shoots*, i.e. polycyclic branches originating in late flushing of subterminal lateral buds. Furthermore, the presence of forks - development of two or more leaders - and ramicorns - big branches with a steep angle with the trunk -was commonly observed.

The presence of forks and ramicorns is related to different factors. Portefaix (1987b) reported that lammas shoots were involved in 70 p. 100 of the defects at early ages (9-year old). Tree age had also an important effect: the number of defects increases until the trees were 11 years old, where it reached a maximum, and then decreased until the trees were 20 years old when these defects rarely occurred (Rabat, 1985). Therefore, the largest number of forks and ramicorns are located in the basal part of the stem, where the timber economic value is the highest.

Given the importance of the branching defects in the Centre provenance of Corsican black pine at early ages, it was necessary to study the changes of these traits over time. The aim of this study was to investigate the use of juvenile branching traits as predictors of the branching habit at a more adult stage. For that purpose, a sample of trees was measured seven years after their first evaluation, which was reported in a previous work by Portefaix (1987b). The change in the frequency of forks and ramicorns over time and the influence of different whorl traits were studied.

MATERIAL AND METHODS

Data were collected in an open progeny test of Corsican black pine —INRA no. 2.426.2— located in the central part of France on a deep, sandy soil. It was planted in 1979 with 2/0 seedlings. The progeny test included 48 families from four stands of the Centre provenance, 14 families from four Corsican natural stands, and four control seedlots from Corsican natural stands. Measurements were taken at two different ages on a random sample of 337 trees from 13 families belonging to the Centre provenance. Families were classified into two groups: in the first one (Group A) families frequently had polycyclic branches; in the second group of families (Group B) polycyclic branches were much less frequent. The branching habit traits measured at age 9 in the 6th, 7th and 8th whorl, i.e. those whorls growing in the 6th, 7th and 8th growing season (Portefaix, 1987b) and used in this study are the following: Number of forks and ramicorns, number of polycyclic branches and branch angle score (in a subjective scale, 1: flat angle with horizontal <25º; to 4: narrow angle, >75º).

The second set of measurement was made in the same whorls when the trees were 16 years old (Table 1).

TABLE 1

BRANCHING TRAITS MEASURED IN THE 6TH, 7TH AND 8TH WHORL, OF THE TREES SAMPLED FOR THE STUDY. TREES BELONGED TO A PROGENY TEST OF 16-YEAR OLD CORSICAN BLACK PINE

Caracteres de ramificación medidos en los verticilos 6.°, 7.° y 8.° de los árboles muestreados en el estudio y situados en un ensayo de progenies de Pinus nigra corsicana *de 16 años de edad*

Trait	Description	Units
NB	Number of branches	count
DBRAN	Size of branches assesed as the ratio of the mean diameter of three branches and that of the stem at the level of the whorl	ratio
ANG	Angle of branches as desribed in Fig 1. (1: narrow angle, 4: flat angle)	scale
ANGM	Angle maximum, i.e. of the most narrow branch	scale
LENGW	Length of the whorl (vertical distance among the insertion points of the lower and the higher branch	cm
CIRC	Circumference of the stem at the level of the whorl	cm
NRPOL	No of polycyclic branches per whorl	count
NPINS	No of polycyclic branches inserted in the trunk, per whorl	count
NRAM	No of ramicorns	count
NFORK	No of forks	count
Origin	Origin of Ramicorn: R1: death of leader, R2: lamma shoot, R3: intrinsic factors	

Change in the number of forks and ramicorns over time was determined for each whorl separately. A Wilcoxon paired comparison (Steel, Torrie, 1980) was used to test change in the number of forks and ramicorns between ages 9 and 16. When the number of pairs was greater than 25, a normal approximation was used. Then, a classification of defects was made, based on their changes. The following classes were recognised.

a) Stable defect. No changes observed between the two ages. Ramicorns (R) and forks (F) were classified into three types according to their likely origin (1: lammas shoot, 2: death of leader, 3: intrinsic factors).
b) Unstable defect. Change after the first evaluation.
   R->0, Ramicorn observed at age 9, but not at age 16.
   F->0, Fork observed at age 9, but not at age 16.
   F->L, Fork whose branch became the leader.
   F->R, Fork observed at age 9, that changed to ramicorn at age 16.
   0->R, New ramicorn, not observed at age 9.
c) Lammas shoot inserted in the stem. This is a local defect observed in this provenance: because of the diameter growth of the trees, lammas shoots are progressively inserted in the trunk before natural pruning occurs (Fig. 1). Frequency of this defect was recorded.

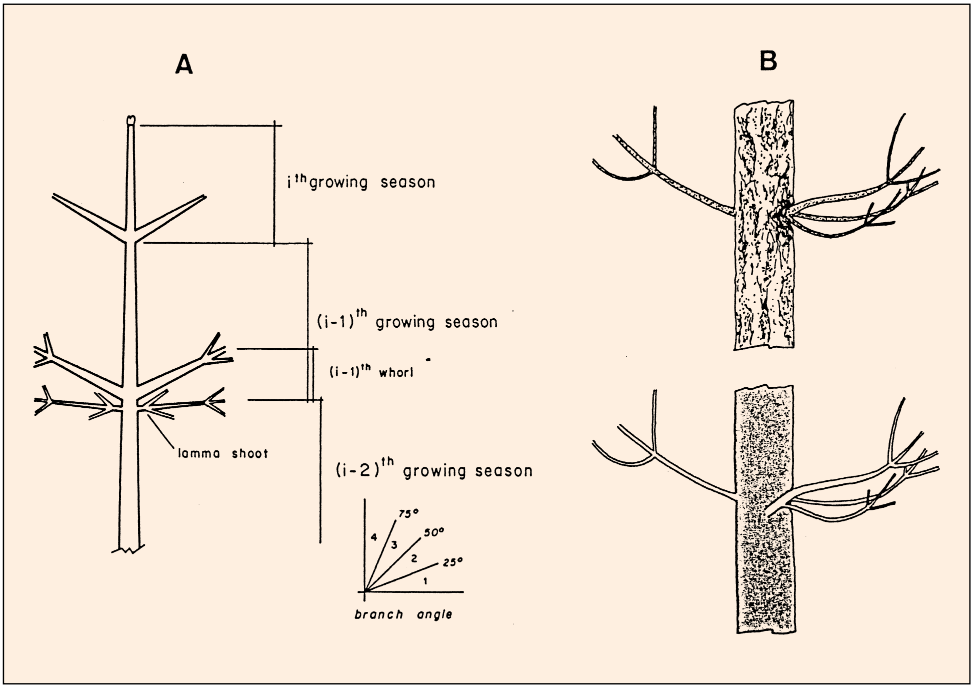

Fig. 1.—Whorls and angle classes in the study, where *i* is the growing season when the tree was measured (i.e. the age of the tree) (A), and scheme of a polycyclic branch inserted in the stem (B)
Nomenclatura utilizada en la denominación de verticilos y los ángulos de ramas, donde i *es la estación de crecimiento cuando se midió el árbol (es decir, la edad del árbol) (A), y esquema de una rama policíclica insertada en el tronco (B)*

For stable ramicorns, an ANOVA of frequencies, based on the Log-linear model, was made. The statistical effects were ramicorn origin, whorl and age of tree. The change in frequencies of ramicorn-type in highly polycyclic families (Group A) and in low polycyclic families (Group B) was evaluated using a comparison of frequencies. The relationship between whorl structure (i.e. number and main characteristics of branches - Table 1) and ramicorn change was studied in the 7th whorl, the one with the greatest number of ramicorns. Four classes of trees were established according to ramicorn change:

Class 1: Tree without ramicorns at both ages
Class 2: Tree with new ramicorns
Class 3. Tree with stable ramicorns
Class 4. Tree with missing ramicorns

A discriminant analysis for classes was conducted using a quadratic function of quantitative traits, since the within-class covariance matrices were not equal (Afifi, Clark, 1990). Traits with a clear mean-variance relationship were transformed using a

Log transformation. The statistical package SAS (SAS Institute Inc., 1987) was used for analysis.

RESULTS

Change over time in frequency of forks and ramicorns

Fork and ramicorn frequencies of the three whorls scored at ages 9 and 16 on the 337 trees are presented in Table 2. The most important observation with regard to change over time was that the number of ramicorns decreased in the 6th and 7th whorl, whereas it increased in the 8th whorl. The overall proportion of each kind of defects when considering their change from age 9 to age 16 are presented in Figure 2.

TABLE 2

FREQUENCY OF FORKS AND RAMICORNS AT AGE 9 AND 16 FOR EACH WHORL, AND P-VALUES OF THE WILCOXON TEST OF RANKS FOR PAIRED SAMPLES

Frecuencia de bifurcaciones y ramicornes a la edad de 9 y 16 años, por verticilo, y significación de la prueba de Wilcoxon de muestras emparejadas

	6th Whorl			7th Whorl			8th Whorl		
	age			age			age		
	9	16	P	9	16	P	9	16	P
Forks	3	2	—	49	2	0.001	25	1	0.001
Ramicorns	47	32	0.027	116	90	0.011	27	43	0.044

If no. of pairs is greater than 25, a normal approximation was used. Sample of 337 corsican laricio pine.
Si el número de pares es mayor de 25 se utiliza una aproximación normal. Muestra de 337 árboles de *Pinus nigra corsicana*

Stable defects

Considering all the branching defects observed at both ages, only 31.6 p. 100 of them were stable, in the sense that we could recognise them after seven years. If the defects were considered separately, only 6.5 p. 100 of the forks, and 27 p. 100 of the ramicorns could still be observed after seven years. Stable ramicorns were 40 p. 100 of all the ramicorns in 7th whorl, and similar values in the 6th whorl. Lammas shoots were the main cause of ramicorns in the 16-year-old trees (Table 3). Sixty three percent of the ramicorns were observed on branches showing this axillary growth. Thirty seven percent of the observed ramicorns originated in whorls of branches with close angle.

Frequencies of the different types of ramicorn at both ages, and results of the ANOVA performed on the frequencies with the Log-linear model, are presented in

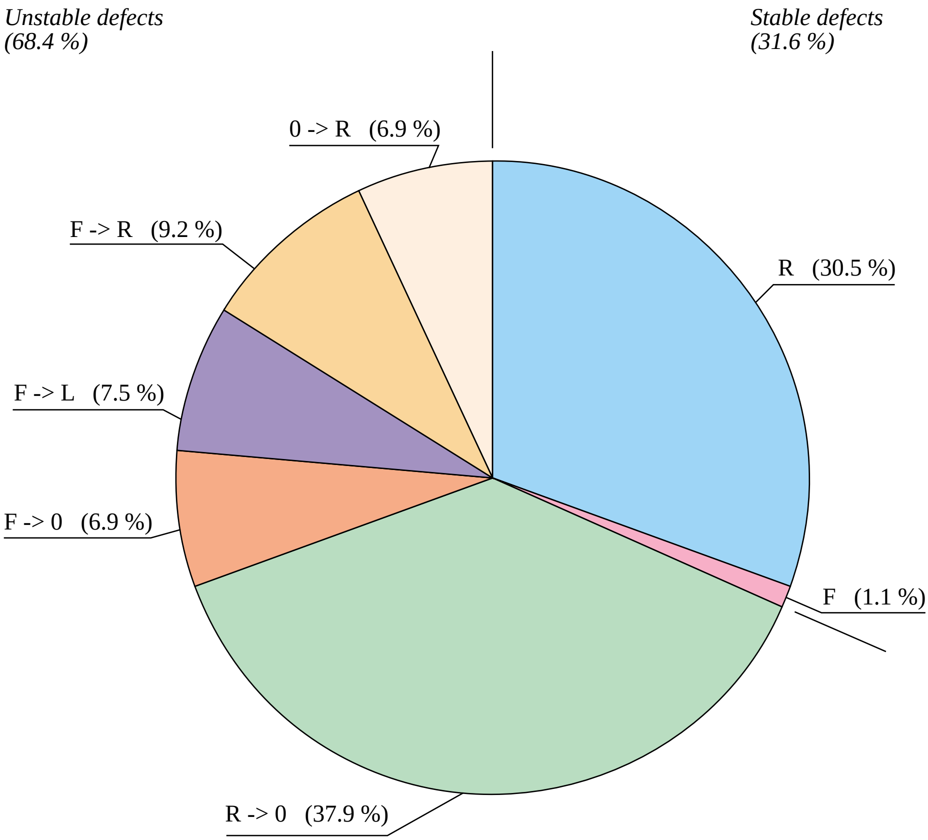

Fig. 2.—Classification and proportions of the different types of defects of the whorls according to their change over time. R=ramicorn, F= Fork, R->= (F->0)= Ramicorn (fork) observed at age 9 but not at age 16, F-> L= fork whose branch became the leader, F->R= fork observed at age 9, that changed to ramicorn at age 16

Clasificación y proporciones de los diferentes tipos de defectos de los verticilos según su cambio. Las abreviaturas son: R=ramicorn, F= bifurcación, R->= (F->0)= Ramicorn (bifurcación) observada a los 9 años pero no a los 16, F-> L= bifurcación en el que la rama se convierte en la guía, F->R= bifurcación observada a los 9 años que cambia a remicorn a los 16

Table 3. The age of measurement of the trees did not have a significant effect on ramicorn frequencies. So a clear patter for the change over time of the frequencies of the different types of ramicorn did not appear. This was enhanced by the quite significant effect of the interaction Age * Type (Table 3) which indicated a specific evolution of the frequency of each ramicorn-type. Whorl effect, ramicorn - type effect and interaction Whorl * Type were all significant (P-values < 0.01): the 8th whorl had a larger proportion of ramicorns coming from close angle whorls by comparison with the other whorls.

TABLE 3

FREQUENCIES (AND PERCENTAGE) OF RAMICORNS, BY ORIGIN AND RESULTS OF THE MAXIMUM-LIKELIHOOD ANALYSIS OF VARIANCE PERFORMED ON THE RAMICORN FREQUENIES OF THE THREE WHORLS

Frecuencias (y porcentajes) de ramicornes, según su origen, y resultados del análsis de varianza Log-lineal realizado a partir de las frecuencias de ramicornes de los tres verticilos

Origin of ramicorn	6th whorl		7th whorl		8th whorl	
	age 9	age 16	age 9	age 16	age 9	age 16
Death of leader*	2 (4 %)	1 (3 %)	2 (2 %)	16 (18%)	0 (0 %)	7 (16 %)
Polycyclic ramicorn	32 (68 %)	22 (69 %)	78 (67 %)	44 (50 %)	15 (56 %)	10 (23 %)
Intrinsic ramicorn	13 (28 %)	9 (28 %)	36 (31 %)	28 (32 %)	12 (44 %)	26 (60 %)
Total	**47 (100 %)**	**32 (100 %)**	**116 (100 %)**	**90 (100 %)**	**27 (100 %)**	**43 (100 %)**

Maximum-Likelihood ANOVA of frequency of ramicorns

Source	DF	Chi-square	P
Whorl	2	67.66	0.000
Age	1	1.30	0.255
Origin	1	7.45	0.006
Whorl*Age	2	4.56	0.102
Whorl*Origin	2	14.14	0.001
Age*Origin	1	3.24	0.072
Likelihood Ratio	2	3.80	0.047

* Not considered in the analysis.

Unstable defect

– Ramicorn observed at age 9, but not at age 16 (R->0).

Quantitatively, this was the most important change, because it represents 37.9 p. 100 of all the defects (Fig. 2) and 55 p. 100 of all the ramicorns in the 7th whorl with no significant differences among the three whorls. Branch angle at age 16 seemed not to be still stabilised, since the branches were still alive. But differences among the three whorls were lower at age 16 than at age 9 (Fig. 3). Therefore, the flattening of the branch angle with age could be a reason for the disappearance of ramicorns.

– Fork observed at age 9, but not at age 16 (F->0).

This account for 6.9 p. 100 of all the defects, and it was a quantitatively important change for forks, since more than 28 p. 100 of them disappeared. It can be assumed that this evolution is very close to the first case. When the whorl was young, it was difficult to distinguish between a fork and a ramicorn. That is the reason why this kind of evolution was more important for the 8th whorl, which was only one year old in the first evaluation.

– Forks whose branch became the leader (F->L).

This accounted for 7.5 p. 100 of the defects (30 p. 100 of the forks) for the 7th whorl, and quantitatively it was as important as the previous type. After the death of the leader, a competition for dominance appears, and the branches elaborate reaction wood in order to become the leader. If only one branch takes this position, there is a change in the orientation of the tree axis, due to the growth of the new leader. But diameter growth could eliminate the external defect after several years.

– Fork observed at age 9, that changed to ramicorn at age 16 (F->R).

This accounted for 9.2 p. 100 of all defects, but it was the most frequent change for the forks (37 p. 100). This kind of change was more important for the 8th whorl (1-year old in the first measurement). The origin was the same as in the forks not observed (ii: F->0), but the change was smaller and the impact was greater for the stem quality.

– New ramicorn, not observed at age 9 (0->R).

The year effect was very important in this case. In the 6th and 8th whorl, more new ramicorns appeared than in the 7th whorl (respectively, 33 p. 100 and 48 p. 100 against 10 p. 100). But this year effect was partially explained by the number of ramicorns the different whorls, and precision was lower for the latter.

When de family groups (A or B) were considered, differences were observed in the number of ramicorns present at age 16 but not scored at age 9 (Fig. 4). Fifty three percent more new ramicorns appeared in the low polycyclic families (group B), whereas only 33 p. 100 appeared in group A. This difference was in close agreement with the fact that forks and ramicorns of group B families mainly came from the close angle of branches in the whorl. Conversely, the percentage of missing ramicorns was the same for the two groups.

Lammas shoots inserted in the trunk

The same number of lammas shoots was observed at age 9 and at age 16. So, with diameter growth of the stem, the additional whorl of the branch was progressively inserted in the trunk. The longest lammas shoots - with an additional whorl far from the stem - did not yet show inserted branches, whereas the smallest ones - with an additional whorl closer to the stem - generally already showed insertion of the additional whorl. In the near future, the longest lammas shoots, which are the biggest, should progressively inserted in the trunk, before any natural pruning could arrive. So the defects of these big inserted lammas shoots should be much greater than the small ones already inserted.

Quantitatively, the number of lammas shoots inserted in the stem was as important as the ramicorn number. The influence of the year was important only for the expression of polycyclism. The ratio NPINS/NRPOL was quite constant over the three whorls (0.3-0.4), and appeared to be independent of the environmental conditions of the year that lead to the expression of a second axillary growth. This ratio was also independent of the family group: in group A (where NRPOL=1.2 in 7th whorl) it was equal to 0.37, and in group B (NRPOL=0.29) it was equal to 0.30.

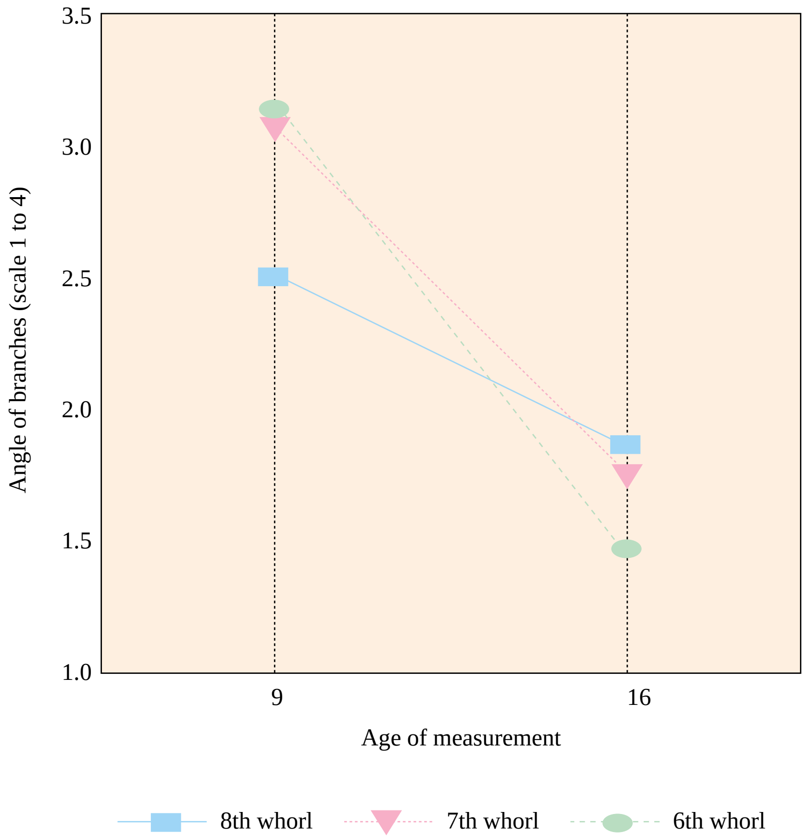

Fig. 3.—Change of the mean angle of branches (ANG) between age 9 and age 16 for the three whorls
Cambio del ángulo medio de las ramas (ANG) entre los 9 y los 16 años para los tres verticilos

Relationship between whorl structure and ramicorn change

The different traits involved in the whorl structure enabled the characterisation of the four classes of ramicorn change over time, as shown by a discriminant analysis. Table 4 presents the simple statistics of the four classes. First of all, trees without ramicorns (Class 1) at both ages were characterised by many branches with a flat angle of insertion and a low frequency of lammas shoots. The presence of new ramicorns (Class 2) could be related to few branches with a narrow branch angle which allowed a greater competition between branches and the leader. Trees with stable ramicorns (Class 3) were characterised by few big branches with a narrow initial angle of insertion and a high number of lammas shoots. Differences between the four classes of trees were clear (Table 5), except for class 4 (missing ramicorns). This class was mainly mixed with class 1 (no defects: 43 p. 100) and with class 3 (stable ramicorns: 20 p. 100). In conclusion, trees which showed more ramicorns an age 16 (Classes 2 and 3) were characterised by a small number of branches, a high frequency of lammas shoots an a narrow angle of insertion of branches. Indeed, this whorl structure led to a higher internal competition between branches and the leader.

TABLE 4

SIMPLE STATISTICS OF FOUR CLASSES OF RAMICORN CHANGE OVER TIME IN 337 CORSICAN BLACK PINE TREES, MEASURED IN THE 7TH WHORL

Estadística descriptiva de cuatro clases diferenciadas según el cambio habido en los ramicornes de 337 árboles de Pinus nigra corsicana, *medidos en el 7º verticilo*

Variable	Class 1		Class 1		Class 2		Class 3	
	Mean	CV	Mean	CV	Mean	CV	Mean	CV
ANG9	2.86	21.3	3.27	19.7	3.55	15.2	3.24	20.4
ANG16	1.6	39.6	2.27	28.4	1.88	42.9	1.87	37.2
NB	6.73	28.9	5.72	36.7	5.76	36.9	6.61	32.9
DBRAN	1.37	18.6	1.32	16.2	1.56	26.5	1.39	22.7
LENGW	7.37	47.6	9.18	21.1	10.88	50.4	9.31	49.7
NRPOL	0.34	291.2	0.73	213.1	1.55	104.8	1.37	122
	n=200		n=11		n=52		n=49	

Class 1: Tree without ramicorns.
Class 2: Tree with new ramicorns.
Class 3. Tree with stable ramicorns.
Class 4. Tree with missing ramicorns.

DISCUSSION

Defect change over time

The presence of forks and ramicorns is considered to be the main factor reducing final bole quality of Corsican black pine (Portefaix, 1987b; Arbez, 1980). These defects often appear at early ages, specially when trees are growing in good soil conditions, but large changes occur over time.

In the test analysed, forks were not quantitatively important at mature ages, because of the strong evolution from earlier estimations. Ramicorns were much more important than forks, but a great change over time was observed for this trait. The most important change occurred in the younger whorls. Early evaluation (at age 9) was not very effective since the distinction between fork and ramicorns was not very clear, and since the prediction of the branch evolution over time was difficult. Therefore, at these ages, it seems better and more simple to consider only one branch defect for forks and ramicorns and to count the number of defects per whorl or per tree.

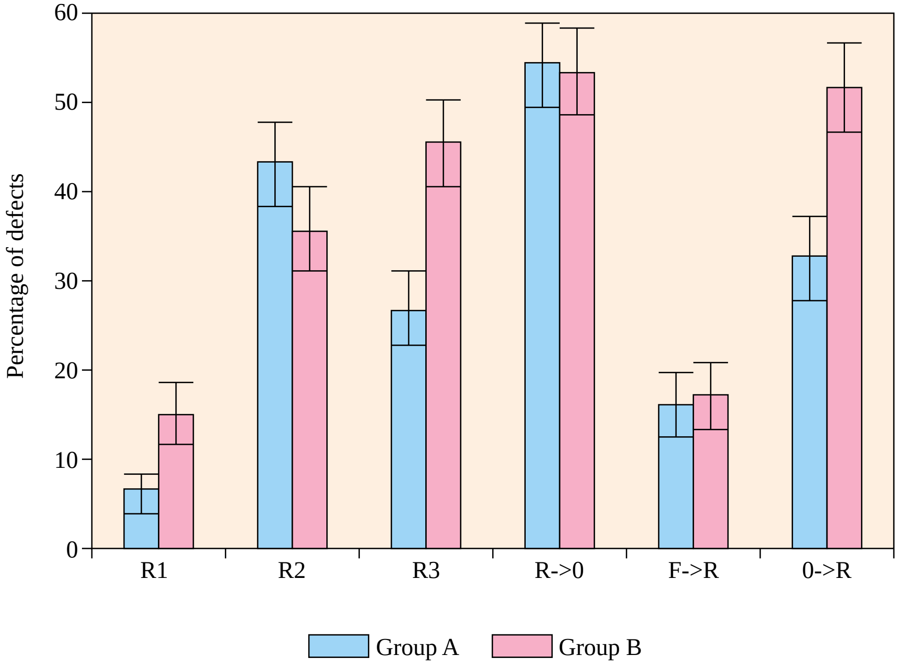

Fig. 4.—Percentage of the different types of defects at age 16 respect their number at age 9 for the two groups of families: Group A= highly polycyclic families, Group B=low polycyclic families. Measured in a sample of 337 Corsican black pine trees

Porcentaje de los diferentes tipos de defectos a los 16 años respecto a los existentes a los 9 años para los dos grupos de familias: Grupo A= familias altamente policíclicas, Grupo B= familias poco policíclicas. Muestra de 337 árboles de Pinus nigra corsicana

Ramicorn change can be analysed in different ways. If we focus on the origin of defects, lammas shoots seem to be an important cause of ramicorn occurrence (Portefaix, 1987b). Such conclusion was also reported in other pine species such as jack pine (*Pinus banksiana* - Rudolph, 1964) and Scots pine (*Pinus sylvestris* - West, Ledig 1964; West, Rogers, 1971). Lammas shoots could be observed even seven years after the first notation.

Change of polycyclic ramicorn over time appeared to be somewhat different from the change of ramicorn originated in narrow branch angle. Moreover, frequency of lammas shoot occurrence greatly varied from year to year (i.e. among the different whorls). Thus, some other internal factors should determine the presence of ramicorn branches in low polycyclic whorls. Since these internal factors were complex and not easily measured, branch angle of the whorl could be used instead.

Disappearance of ramicorns could be explained by changes in branch angle and stem diameter. At age 16, branch angle was still not stable, and differences between families were rather similar between the two ages. Various aspects of photosynthetic capacity and competitive ability of the branches influence the branch evolution (Honda, Fischer, 1978).

TABLE 5

DISCRIMINANT ANALYSIS CLASSIFICATION SUMMARY OF FOUR CLASSES OF RAMICORN CHANGE OVER TIME OF 337 CORSICAN BLACK

Resumen de la clasificación obtenida por análisis discriminante de las cuatro clases diferenciadas según el cambio habido en los ramicornes de 337 Pinus nigra corsicana

From CLASS	Observations classified into CLASS				
	Class 1	**Class 2**	**Class 3**	**Class 4**	**Total**
Class 1	**164**	3	16	17	200
	82	*1.5*	*8*	*8.5*	*100*
Class 2	1	**10**	0	0	11
	9.1	*90.9*	*0*	*0*	*100*
Class 3	6	5	**33**	8	52
	11.5	*9.6*	*63.5*	*15.4*	*100*
Class 4	21	1	10	**17**	49
	42.9	*2*	*20.4*	*34.7*	*100*
Total	192	19	59	42	312
Percent	*61.54*	*6.09*	*18.91*	*13.46*	*100*

Number of Observation and *Percent* Classified into CLASS. In bold: number of observation well classified.
Número de observaciones y porcentaje clasificado en cada clase. En negrilla: número de observaciones bien clasificadas.

From a mechanical point of view, the branch shape could be explained as a result of growth patterns and weight variations of the branches. This has been shown for *Pinus pinaster* (Castéra, Morlier, 1991). Given the relationship between growth and deflection, changes of branch angle can be evaluated as a function of growth 'units' in *Picea abies* (Colin, Houllier, 1992). Radial growth of the stem leads to the inclusion of the branch. Seven years after the first evaluation, there is a large change in the insertion angle, as it is shown from the modelling of branch growth (Cannel *et al*., 1988). Thus differences in initial whorl angle may produce differences in whorl quality as a result of the tree growth.

In a 10-year old *Pinus nigra calabrica* progeny test, Arbez, Millier (1972) reported a change of 10º on the 5th whorl branch angle for a distance from the stem varying from 5 to 15 cm. This curvilinear shape of the branch, from its insertion point to its distal part, can also be involved with the apparent increase, over time, of the insertion angle of the branches: after several years, the radial growth of the stem includes the proximal close angle part of the branch, and the distal part is the only one observed. In the same way, Matziris (1989) found a reduction of 30º in the branch angle from the first to third whorl in several clones of *Pinus nigra*. Of course, the change of the branch angle over time is a combination of the two factors described in the two previous paragraphs.

The change of ramicorn branches could also be conditioned by the presence of a smaller number of branches per whorl, with a large branch angle, and a high level of polycyclism. Branch angle is a highly heritable trait (Arbez, Millier; 1972; Portefaix, 1987a; Polk, 1974; Matziris, 1988) which seems to be regulated by the interaction of factors such as gravity, light and internal genetic mechanism (Zimmerman, Brown, 1971). Morgan Cannel (1988) analysed the support cost of different branch designs. They concluded that greatest savings are made by angling the main branch upward the horizontal. The number of branches per whorl also varies from a moderate to highly heritable trait (Arbez, Millier, 1972; Polk, 1974). These traits are also related to the presence and change of ramicorns.

Consequences for early selection

Several conclusions for early selection can be drawn from this study. First of all, notations made at 9 years old (six years after planting) appear to greatly over-estimate the actual number of defects at a more adult stage. Moreover, preliminary results showed that age-age genetic correlation was not very high (about 0.5) for branch angle and polycyclism assessed on whorls spaced with a lag of six years (data not shown). Thus, it would be more advisable to delay the age of notation and selection of branching defects after 15 years old. But more studies are necessary to better appreciate the actual age-age genetic correlations and their impact on early selection efficiency. Another aspect is the value of the genetic correlation between branching habit traits and vigour. Portefaix (1987a, 1987b) reported slightly unfavourable genetic correlations between height and polycyclism frequency of fork score. New studies are also necessary on that aspect and on the evolution with age of this correlation (e.g. correlation between juvenile height and more adult branching habit). If early selection is maintained in the future, a combination of all the whorl traits as described before (i.e. polycyclism, branch angle, number and mean diameter of branches) would be more convenient. Finally, a strong selection against lammas shoots would be advisable since these supplementary whorls on branches may be progressively inserted in the stem before natural pruning occurs. These big defects will not be prevented unless specific selection of artificial pruning, or both, are made.

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RESUMEN

Cambio con el tiempo en los defectos de ramificación de *Pinus nigra var. corsicana* de la procedencia Francia Central

Se ha estudiado el cambio habido en los defectos de ramificación observados en un ensayo de progenies de *Pinus nigra* Arn. ssp. *laricio* (Poir) Schwarz var. *corsicana* (Loud) Franco tras siete años de su primera evaluación. Se midieron 337 árboles a las edades de 9 y 16 años. Se analiza el cambio de la frecuencia de bifurcaciones y ramicornes y la influencia de diferentes caracteres de los verticilos en estos cambios. El porcentaje de bifurcaciones y ramicornes que se reconocieron a la edad de 16 años fue solo del 31.6 p. 100 de los registrados a los nueve años. Alrededor del 55 p. 100 de los ramicornes desaparecen, debido a un aplanamiento del ángulo de las ramas con la edad. Los árboles con ramicornes estables se caracterizan por un ángulo de ramas inicial muy agudo, un alto grado de policiclismo en las ramas y un gran diámetro de ramas.

Debido al crecimiento del diámetro, los verticilos adicionales formados en las ramas policíclicas pueden insertarse progresivamente en el tronco antes de que se produzca la poda natural, lo que ocasiona un efecto local de gran importancia. Se discuten las consecuencias con vistas a una selección precoz.

PALABRAS CLAVE: *Pinus nigra*
Defectos de ramificación
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