The taxonomic status of oaks (*Quercus* spp.) in Breen Wood, Co. Antrim, Northern Ireland

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ABSTRACT

The taxonomic status of oaks (*Quercus* spp.) at a National Nature Reserve, Breen Wood, Co. Antrim, Northern Ireland, was assessed using a combination of eight leaf characters and pollen viability. Four types of tree were recognised: 'pure' *Q. petraea*, F_1 hybrids between *Q. petraea* and *Q. robur*, and two types of backcrossed hybrids – one, morphologically indistinguishable from 'pure' *Q. petraea* but with low pollen viability and the other, morphologically intermediate but with a comparatively high pollen viability. One 'pure' *Q. robur* tree was identified. It is argued that the wide range of backcrossed hybrids present in Breen Wood may be the result of extensive forest clearance in the past, which has promoted introgression.

INTRODUCTION

Variational patterns within and between populations of oaks, *Quercus robur* L. and *Q. petraea* (Matt.) Liebl., have been extensively described (e.g. Carlisle & Brown 1965; Cousens 1963, 1965; Rushton 1978, 1979; Wigston 1974, 1975). The general conclusions derived from these various researches have been that much of the variation can be ascribed to introgressive hybridisation, although authors might disagree on the levels of such hybridisation within populations.

In the course of a preliminary survey of variation in oaks in Northern Ireland (Rushton 1979) it became apparent that a proportion of the trees at Breen Wood, Co. Antrim (GR 34/124.336) were of morphologically intermediate type. This 21 ha woodland is of interest as it is said to represent one of the few remaining stands of natural oakwood in Northern Ireland and has been, in consequence, awarded the status of a National Nature Reserve. Because of the importance of the site, it was decided to resample the woodland more extensively and to use pollen viability studies as an adjunct to leaf morphology in trying to determine the taxonomic status of the trees. Similar studies on oak have already been described by Olsson (1975) and Rushton (1978), and many parallel studies have been carried out in other genera, e.g. *Primula* L. (Woodell 1965), *Agrostis* L. (Bradshaw 1958).

METHODS

During spring 1981, 80 trees from Breen Wood were selected using a random walk. These trees were numbered, marked and mapped so that they could be sampled subsequently for leaf and fruiting material. In May 1981, a sample of catkins was removed from each tree, placed in individual paper envelopes and transported back to the laboratory. The catkins were placed on clean microscope slides and left undisturbed for 12 hours to allow the anthers to dehisce. Before staining, each sample was gently shaken to release any remaining pollen. The pollen was stained with aniline blue in lactophenol and unstained pollen (inviable) estimated for each tree in a count of at least 200 grains.

In mid-summer 1981, leaf samples were collected consisting of five midshoot leaves per tree from a standard canopy position, i.e. at a height of 6 m on the southern aspect (Rushton 1974, 1978). These leaves were assessed for eight characters broadly corresponding to those of Rushton (1978). These were:

1. Lamina shape or obversity.
2. Lobe depth ratio (an estimate of leaf dissection).

3. Petiole ratio (an estimate of relative petiole length).
4. Percentage venation (an estimate of intercalary veining on the leaf).
5. Number of lobe pairs.
6. Basal shape of the lamina.
7. Auricle development.
8. Stellate abaxial pubescence.

Lamina shape, lobe depth ratio and petiole ratio were all assessed by leaf measurement; percentage venation and lobe number were counts; basal shape of lamina, auricle development and stellate abaxial pubescence were assessed on a 0–4 index scale using a set of standard leaves for comparison. This range of characters is more restricted than that used in the earlier study (Rushton 1978).

In September and early October 1981, further visits were made to collect fruiting material. However, due to a very poor mast year, only 22 of the previously sampled trees had produced acorns, which were, for the most part, immature and failed to mature through the autumn. Fruit characters have not therefore been included in this study.

DATA HANDLING

In order to provide a morphological basis for comparison, the morphological data for the 80 Breen Wood trees were combined with type population data of *Q. robur* (25 trees) and *Q. petraea* (22 trees) used in an earlier study (Rushton 1974, 1978) and analysed using a Principal Component Analysis program (PCA) written in PASCAL for the VAX 11/780 computer. The results presented here are derived from a PCA of the appropriate correlation matrix. PCA provides a multidimensional view of the data, but, as indicated in earlier studies (Rushton 1974, 1978), the first Component is often the most useful in that it separates *Q. robur* from *Q. petraea* at the two ends of the axis with intermediate forms distributed between. The earlier studies had shown that, using a PCA, the two reference populations mentioned above separated clearly, with no overlap. In order to avoid bias in the choice of reference populations, the Breen Wood data were also analysed with other reference populations including population mean values for 'pure' populations using the more restricted character set of this present study. Analysis of 'pure' populations alone, either using individual tree results or population means for the restricted character set, resulted in clear, unequivocal separation of the two types – 'pure' *Q. robur* and 'pure' *Q. petraea*. For comparison with the earlier studies, only the analysis of the Breen data together with the previously reported two reference populations will be considered. The results with other reference populations are substantially similar.

RESULTS

Fig. 1 summarises the results of both the morphological and pollen viability study. The first Component of the PCA separated out the two reference populations with *Q. robur* at the right hand end of the Component. The 80 trees from Breen Wood grouped towards the left hand end of the

TABLE 1. VECTOR LOADINGS FOR THE FIRST COMPONENT OF THE PCA

Character	Vector loading
Lamina shape or obversity	−0.31
Lobe depth ratio	−0.59
Petiole ratio	0.69
Percentage venation	0.68
Number of lobe pairs	−0.34
Basal shape of the lamina	−0.63
Auricle development	−0.82
Stellate abaxial pubescence	−0.71

Vectors standardised so that the sum of elements squared equals the latent root. The first Component accounted for 38.4% of the total variance.

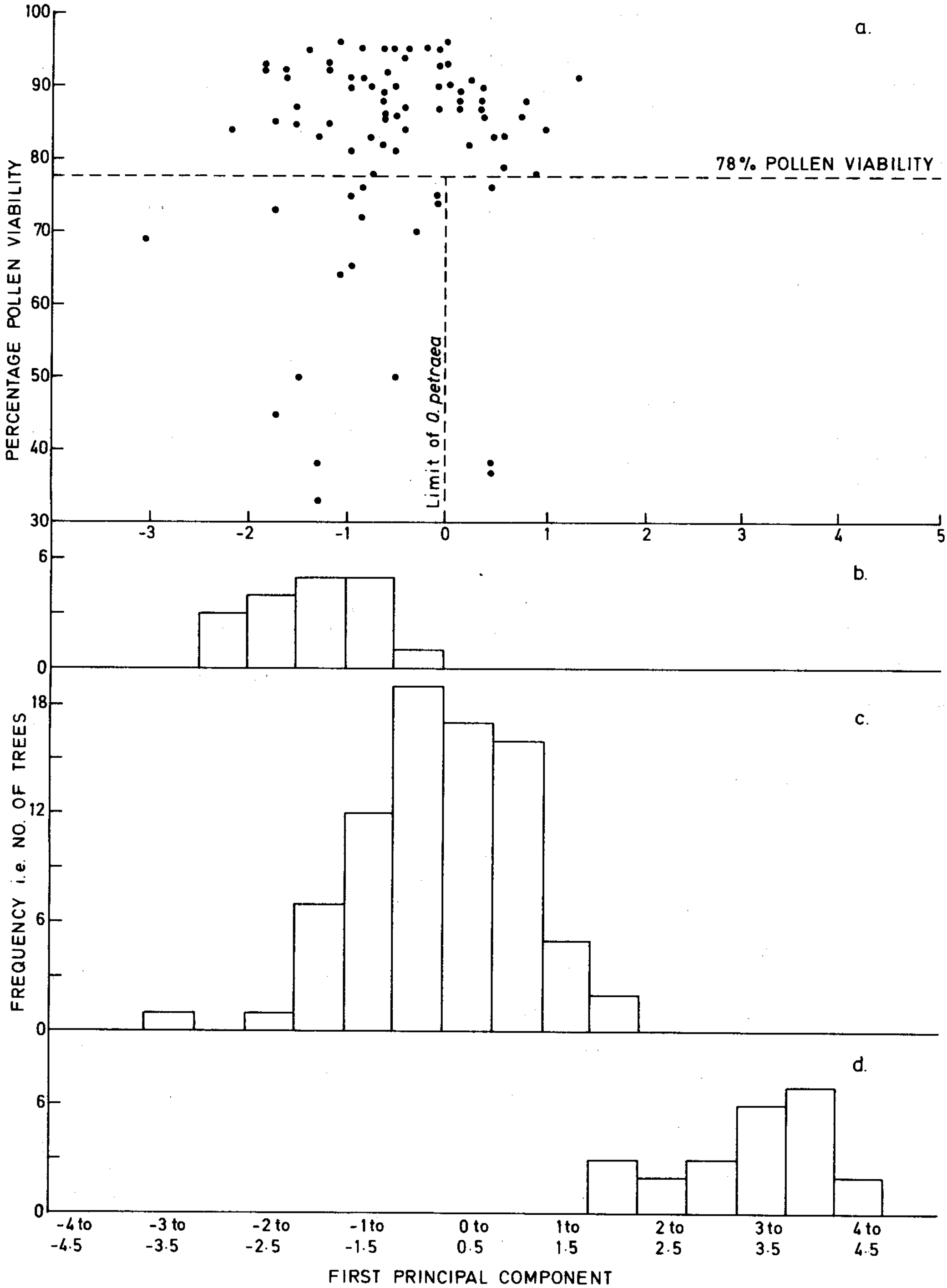

FIGURE 1. PCA of 80 trees from Breen Wood together with a reference 'pure' *Q. robur* population and a reference 'pure' *Q. petraea* population.
a. The first Component of the correlation matrix is plotted against the corresponding percentage pollen viability for each individual tree from Breen Wood.
b,c,d. Frequency distribution of trees along the first Component. b – reference 'pure' *Q. petraea* population; c – Breen Wood population; d – reference 'pure' *Q. robur* population.

Component indicating their *Q. petraea* affinities (Fig. 1a, c). One tree from Breen Wood fell just into the range of the *Q. robur* material. However, a large number of trees (30 out of 80) fell into the intermediate zone between the two reference populations, indicating their intermediate morphology. Examination of the vector loadings for Component 1 (Table 1) indicated that all characters showed significantly high vector loadings although lamina shape and number of lobe pairs were slightly lower than the others. This result is not very dissimilar from that observed in populations considered in earlier reports (Rushton 1978), and is basically similar to the preliminary analysis of Breen Wood oaks (Rushton 1979). On the second Component, the populations retained their integrity but spread along the Component, indicating that this Component was mainly representing within population variation. Thus, on morphological grounds alone these results would indicate that a large proportion of the trees were of hybrid origin.

Consideration of the pollen viability results indicated a much more complex situation. A large number of the Breen Wood trees (48 in all) had pollen viabilities in excess of 85%. Previous results (Rushton 1974, 1978) had shown that among pure trees percentage pollen viabilities as low as 78% might be expected; 62 Breen Wood trees had pollen viabilities above this level. Of the remaining 18 trees, 15 fell within the morphological range of *Q. petraea* and only three in the morphologically intermediate zone. Two of these trees in the intermediate zone had pollen viabilities below 40%. The single *Q. robur* tree had a high value for pollen viability (91%).

DISCUSSION

Examination of Fig. 1a indicates that on the basis of leaf morphology and pollen viability Breen Wood contains four types of tree, broadly divided by the 78% pollen viability line and the limit set for pure *Q. petraea*. These were:

1. Trees with pollen viabilities generally in excess of 85% and within the morphological limits of pure *Q. petraea*.
2. Trees with somewhat lower pollen viabilities (between 80 and 90%) and of intermediate morphology.
3. Trees with pollen viabilities below 78% but morphologically within the limits set by *Q. petraea*.
4. Trees with very low pollen viabilities and morphologically intermediate.

A fifth category would contain the single tree which overlaps the *Q. robur* population on this Component. Trees in the first category on the basis of both leaf morphology and pollen viability can be regarded as 'pure' *Q. petraea*; those in the fourth category, on the basis of both their morphology and very low pollen viability can be regarded as F_1 hybrids. The trees in the second category probably represent various backcross hybrids very similar to those previously studied (Rushton 1974, 1978). The problematical category is the third since no similar trees were observed in the earlier survey (Rushton 1978). However, Olsson (1975) reported some trees with low pollen viability which on morphological grounds would be classed as 'pure'. Indeed, 14% of his *Q. petraea* samples and 8% of his *Q. robur* samples had pollen viabilities below 70%. In the case of Breen Wood, nine trees out of 57 morphologically *Q. petraea* trees had pollen viabilities below 70% (i.e. 15.8%) and, using the 78% pollen viability level argued above, 15 trees or 26.3% would be below this value. On this basis, the Breen Wood results do not differ greatly from those of Olsson (1975). He accepted the low levels of pollen viability in 'pure' trees as part of the natural range of variation expected for a tree species. However, he was able to show that as the samples became more intermediate the percentage of trees with low pollen viabilities increased. Certainly, Breen Wood would not fit this pattern. An alternative suggestion for the status of the trees in category 3 is that they represent backcrossed hybrid individuals which after several generations of backcrossing have completely assimilated the alien genes but have not regained fertility.

The vegetational history of Breen Wood indicates substantial disruption which might have provided opportunities for extensive backcrossing. Cruickshank & Cruickshank (1981) investigated the development of soil profiles at Breen Wood and incorporated into their study aspects of the vegetation history. Using pollen analysis they were able to recognise consistently eight pollen zones:

8. Present oak-birch forest.
7. Birch forest.
6. Forest recovery led by birch in the grass-dominated later stages of the long, major clearance.

5. Major clearance – heath phase.
4. Partial clearance of forest shown in decline in tree pollen.
3. Oak forest.
2. Early clearance – heath phase.
1. Mixed forest.

There were at least two major forest clearances, the first lasting about 200 years from approximately 0 to 200 AD and a further clearance of 865 years duration extending from 510 to 1375 AD.

Introgression in closed, stable populations of long-lived species like *Q. robur* and *Q. petraea* is likely to be relatively slow. If, however, the population is subject to large-scale removal of adult trees, followed by regeneration from seed derived from survivors or trees in the immediate vicinity, then introgression could possibly proceed at a far faster rate. In the case of Breen Wood, the recovery of the forest was relatively fast, suggesting a seed source relatively close, i.e. from survivors of the clearance. It is envisaged that at Breen Wood during both forest clearances, oaks survived in small numbers, these being *Q. petraea*, a small number of *Q. robur* trees and hybrid trees. When the forest re-established itself, these trees provided a pool of both pure and backcrossed acorn progeny. Thus backcrossed individuals could have been present in comparatively large numbers in the re-established forest. Over time these would have continued to backcross to (mainly) *Q. petraea* and ultimately would have become morphologically indistinguishable from pure trees. Their hybrid ancestry is still apparent, however, from their low pollen viability. On the other hand, some trees that were backcrossed hybrids retained a much more morphologically intermediate character but with a substantially restored pollen viability. These trees are represented by those in the second category above.

The taxonomic status of oaks at Breen Wood is important because of the designation of the site as a National Nature Reserve. Grazing was recently restricted in the reserve and *Luzula sylvatica* (Huds.) Gaud. has spread throughout the wood and has now taken over large tracts of land. There is little doubt that the presence of *L. sylvatica* in the wood is restricting oak regeneration. If artificial regeneration is to be undertaken, then careful choice of parent trees is vitally important if the taxonomic balance of the oaks in the wood is to be preserved.

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