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## ORIGINAL ARTICLE

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## Geographical variation in phenology of *Quercus petraea* (Matt.) Liebl and *Quercus robur* L. oak grown in a greenhouse

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**Abstract**

Twenty-three provenances of *Quercus robur* and four of *Quercus petraea* were tested in a nursery indoor provenance trial. The provenances were sampled in the northern region of Europe. The study revealed large provenance variation in growth, flushing and leaf yellowing. Provenances from Finland and Norway were slow growing compared with those from Denmark, which showed slower growth than Polish, German, Dutch and British provenances. Northern provenances had a slightly significant earlier flushing than southern provenances. Provenances from the Netherlands and the British Isles ceased growth significantly later than provenances from Finland, Norway and Sweden. No significant correlations were revealed between leaf yellowing and growth, flushing and growth or length of growing season and growth, but provenances with late leaf yellowing tended to have higher growth. Provenance and family variation were compared among five Danish provenances. High population differentiation of quantitative traits ( $Q_{ST}$ ) values were found for phenology and low values for growth. The study confirms that the adaptive potential for *Q. robur* is very high. The implications for the movement of forest reproductive material and gene conservation are discussed.

**Keywords:** *Early test, genetic properties, pedunculate oak, provenance testing, sessile oak.*

**Introduction**

Both pedunculate oak (*Quercus robur* L.) and sessile oak [*Quercus petraea* (Matt.) Liebl.] are keystone species in the deciduous forests of Europe. They are often planted, and substantial quantities of seeds and plants are, and have been, transferred within and between countries (Kleinschmit, 1993; Jensen, 2000; Hubert & Cundall, 2006). Oaks are included in various national tree improvement programmes in many countries and are subject to gene conservation strategies (Turok et al., 1998).

Management of forest trees requires an understanding of the genetic ecological pattern of the trees and possible responses to climatic changes (Rehfeldt, 1999; St. Clair & Howe, 2007). Definition of seed procurement zones is important in relation to commercial transfers of forest reproductive material between countries. Tree breeding and gene conservation of forest resources require definitions of seed zones or breeding zones, i.e. areas of specific climatic

and edaphic properties of importance for the survival and growth of a species (Ledig, 1993; Rehfeldt et al., 1999). The genetic structure and diversity of forest tree populations will undergo dynamic changes due to anthropogenic influences, and climatic changes will probably have major consequences for the growth and survival of oak populations, and demand a high degree of adaptability (Ledig, 1993).

Extensive research has been carried out in Europe on deciduous oaks, mainly to test whether new material was appropriate at new sites (Ducousso et al., 1996). In Denmark, oak provenance field trials were established more than 100 years ago. Observations from more than 30 field trials including more than 200 provenances were combined for seed procurement recommendations (Jensen, 2000); however, these studies lacked important information for specific geographical regions of interest. In northern Europe there are steep climatic gradients for temperature and especially for day length,