Oak tree mortality in Iberia

SIR — Rapid death and decline of the cork oak *Quercus suber*, *Q. ilex* and other oak species is occurring across parts of the Mediterranean. In 1991 more than 1,050 major decline foci were recorded in the approximately 2.2 million hectares of oak forests and plantations in southwest Spain (Fig. 1), including 265 foci of average 21.4 ha in the 0.1 million ha of oak cover in the Parque Natural de Alcornacales (natural oak park) in Andalucia. About half the trees in a focus were dead or dying (R. Montoya, ICONA Madrid, personal communication). Comparable oak decline is occurring in adjacent areas of southern Portugal (Fig. 1), and in Italy, Morocco and Tunisia. As in the still unexplained episodes of oak mortality across central and eastern Europe since about 1900 (ref. 1), Mediterranean oak decline has so far been attributed mainly to drought, pollution and to secondary attacks by insects and fungi.

Between May 1991 and March 1992, at the invitation of the Ministry of Agriculture, Madrid and the University of Algarve, Faro, I examined a range of sites in Iberia where oak had declined. Both tree symptoms and decline distribution suggested the possible spread of a root disease caused by the soil- and water-borne fungus *Phytophthora*. Trees often died suddenly in one or two seasons, and tarry exudations and epicormic shoots indicated root stress. Dying trees often occurred in groups, and large foci were noticeably distributed along streams, valleys or depressions (Fig. 2). Rapid decline was sometimes associated with winter surface-lying water or with recent soil disturbances such as ploughing or road making. A more chronic decline occurred on the dryer hillsides. Maquis shrubs (for example, *Cistus* and *Lavendula*) were also dying on some sites.

On dryer soils, dying trees often had many dead fine feeder roots. On more moist soils some trees also had dead and dying larger roots with necrotic bark lesions. Using apple baits and selective antibiotic media, the highly aggressive exotic root pathogen *Phytophthora cinnamomi* was isolated from roots of affected *Q. suber* and *Q. ilex*, or from associated soil, at eleven of thirteen decline sites investigated by myself and local colleagues (Fig. 1)[2]. *P. cinnamomi* is ephemeral and difficult to isolate under dry conditions[3]. Most positive isolations came from sites where soil had remained moist, and our failure to recover the fungus from two sites may reflect the very dry soil conditions due to recent unseasonal droughts.

P. cinnamomi is an unusually polyphagous pathogen of mainly woody hosts[4], most active in roots at 25–30 °C (ref. 3). Probably indigenous to the New Guinea–Celebes region, it has become widely distributed by man. Its introduction is considered responsible for recent dieback of entire eucalypt forest communities in western Australia and for the mass dying of native chestnuts across the southeastern United States in the early 1900s (refs 3, 4). It was becoming widespread in Europe by the 1940s, causing a major epidemic on the European chestnut[5]. From tree symptoms and from its close association with decline sites, the spread of *P. cinnamomi* is likely to be a major factor in the rapid oak mortality in Spain and Portugal, interacting with winter droughts (a recent climatic feature of affected areas) and with changing land use patterns. This may lead to secondary stress attacks by insects and other fungi. By analogy, *P. cinnamomi* may also be involved in the similar oak declines elsewhere in the Mediterranean.

In addition to its intrinsic significance, the association with *P. cinnamomi* highlights once again the threat posed to forest ecosystems by the introduction of exotic pests or pathogens: a threat which in recent years has been overshadowed by the issues of atmospheric pollution and forest exploitation. Such introductions frequently involve trade, and it is exceedingly difficult to ensure that adequate attention is given to the environmental risks posed by the increasing diversity of world trade, and to safeguard the resulting intercontinental movement of plants, raw materials and manufactured goods. Another concern is that *P. cinnamomi* may represent the sort of organism that could become more damaging under conditions of general climatic warming, either directly through becoming more active at higher temperatures, or indirectly through exploiting stress effects on host vegetation. At present these risks to forest ecosystems cannot reliably be predicted or assessed.

FIG. 2 Rapidly dying *Q. ilex* in a depression (foreground) and more healthy *Q. ilex* on a hillside (background) at an oak decline site in western Spain. *P. cinnamomi* was isolated from roots of *Q. ilex* at this site.

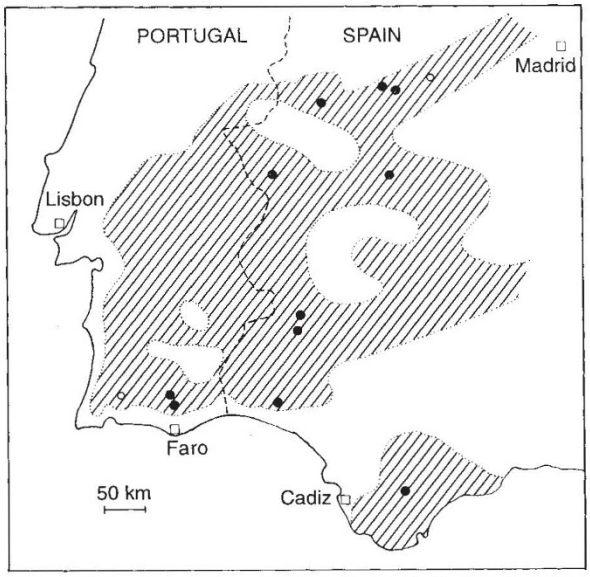

FIG. 1 Main distribution of *Q. suber* and *Q. ilex* (hatched area) in southwest Spain and southern Portugal. ●, Decline site at which *P. cinnamomi* isolated; ○, decline site at which *P. cinnamomi* not isolated. For details see ref. 2.

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