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Associations between crossbills and North American conifers in Scotland

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ABSTRACT

Understanding the habitat requirements of the Scottish crossbill *Loxia scotica* is fundamental to the conservation of this endemic bird which, like other crossbills, specialises in feeding on conifer seeds extracted from cones. Habitat associations of Scottish crossbills and common crossbills *Loxia curvirostra* were determined from a systematic survey of conifer woodland within the range of the Scottish crossbill during January to April 2008. All the commonly planted conifers were producing cones. Scottish crossbills were associated with the amount of coning lodgepole pine *Pinus contorta*, whilst common crossbills were associated with coning Sitka spruce *Picea sitchensis*, lodgepole pine and to a small extent with larches *Larix* spp. The Scottish crossbill's association with lodgepole pine is interesting in view of the notion that Scottish crossbills are adapted to Scots pine *Pinus sylvestris*. Likewise, there was no evidence that common crossbills in the study area during January to April 2008 had an association with Norway spruce *Picea abies*, the tree with which they are normally associated in continental Europe. Lodgepole pine and Sitka spruce cones have thinner scales than those of Scots pine and Norway spruce, respectively, so are probably easier to exploit for seeds than the conifers to which they are assumed to be adapted. This may explain the associations we found.

North American crossbills that specialise on lodgepole pine and Sitka spruce have smaller bills than even common crossbills (the smallest of the western Palearctic crossbills, apart from the two-barred crossbill *Loxia leucoptera bifasciata*). Adaptation to Sitka spruce by common crossbills is unlikely because common crossbills in Scotland largely arrive during irruptions from continental Europe, after which they return in a subsequent season. Therefore, their association with North American conifers in Scotland is temporary. For the resident Scottish crossbills, there is a greater possibility of adaptation to lodgepole pine. However, given the difficulties in identification of old specimens in museums, it was not possible to examine trends in bill size; the prediction is that bill size should decline. Future research needs to distinguish which conifer Scottish crossbills are adapted to as opposed to those which may be temporarily preferred when most profitable.

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1. Introduction

An understanding of habitat requirements is often important for wildlife management, especially for species of conservation concern, where there is the potential for habitat management (Sutherland et al., 2004; Eaton et al., 2005). For most European birds, there is a basic understanding of the main habitats used and diet (Birds of the Western Palearctic series; Fuller, 1982). Therefore, one can infer habitat requirements from where birds occur and what they eat, though detailed research is usually required to confirm inferences (Sutherland, 2000).

One British bird of conservation interest, for which our understanding of habitat requirements is incomplete, is the endemic Scottish crossbill *Loxia scotica*. This species, along with other crossbills, feeds primarily on the seeds of conifers (Newton, 1972; Benkman, 1987). Our poor knowledge of the type of conifer woodland required stemmed from the difficulty in distinguishing Scottish crossbills from common crossbills on appearance (Knox, 1990a). They have a similar plumage and only small differences in size. It was generally believed that semi-natural Scots pine *Pinus sylvestris* forest was the main habitat of Scottish crossbills (Nethersole-Thompson, 1975; Knox in Gibbons et al., 1993), because the species was thought to have evolved within Scots pine woodland after the last glaciation and when the land bridge with mainland Europe was severed, *c.* 7000 BP (Nethersole-Thompson, 1975; Edwards and Ralston, 2003). No other conifers suitable for crossbills colonised Britain at this time. Yew *Taxus baccata* and juniper *Juniperus communis* are also native conifers but their seeds are not eaten by crossbills. By evolving in isolation, the Scottish crossbill became

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Britain's only endemic bird species (Knox in Nethersole-Thompson, 1975; BOU, 1980).

There was concern over the conservation status of the Scottish crossbill because its population size was thought to be small (1500 birds) and its range restricted to the Highlands of Scotland (Nethersole-Thompson, 1975). In addition, ancient native or semi-natural pinewoods are small in extent (18,000 ha) so the habitat itself is threatened (Anon, 1995; Mason et al., 2004). Therefore, the Scottish crossbill was red-listed and placed in category 1 as a species of European conservation concern (BirdLife International, 2004; Eaton et al., 2005). In the Biodiversity Action plan, there is emphasis on more research into its habitat and food requirements (Anon, 1995).

Studies in North America indicate that the different crossbill taxa are adapted to single ('key') conifer species through their bill size (reflected in bill depth) and the width between the palate ridges for de-husking seeds (Benkman, 1989, 1993). On that continent, the habitats (tree species and stand structures) have been less modified by man so that adaptations and co-evolution have taken place uninterrupted over a long period (Benkman, 1999; Benkman et al., 2003). In Scotland, natural woodland cover was perhaps about 50% of the land area during the Mesolithic but, starting in the Neolithic, most was cut down by farmers and/or lost due to climate change (Smout, 1993; Tipping, 1994) so that Scotland had only about 5% woodland cover by the 17th century (Walker and Kirby, 1989), a situation that did not improve until the 20th century (Mather, 1993). The Forestry Commission was formed in 1919 and undertook a concerted effort to increase the amount of conifer woodland (Anderson, 1967). In addition, from the 1950s, the private sector also embarked on large-scale planting of conifers (Warren, 2002). As well as native Scots pine, North American conifers (mainly Sitka spruce *Picea sitchensis* and lodgepole pine *Pinus contorta*) were planted over large areas. Both grow faster than the native Scots pine, and are adapted to a wet climate (Anderson, 1967). Smaller amounts of other non-native conifers (Douglas fir *Pseudotsuga menziesii*, Norway spruce *Picea abies*, European larch *Larix decidua*, Japanese larch *L. kaempferi* and a hybrid form *L.* x *eurolepis*) were also planted. As a result, the woodland cover of Scotland is now about 17% (Warren, 2002), comprising mainly conifer food resources novel to crossbills in Scotland.

This study set out to measure the habitat associations of Scottish crossbills across the current range of conifer types, and across the species' range, comparing these with the habitat associations of common crossbills, which occur sympatrically (Knox, 1990b,c; Summers et al., 2002). This information will help in the conservation of the endemic Scottish crossbill through woodland management. We ignored parrot crossbills *Loxia pytyopsittacus* which also occur, but in only small numbers (Summers and Buckland, 2011). Characteristics of the cones (cone size and scale thickness) were examined because these affect the ability of crossbills to exploit cones (Benkman, 1987). We also discuss the possibility that crossbills are adapting to novel food supplies through changes to their bill morphology (Benkman, 2003).

2. Methods

2.1. Study area and sampling design

The study was carried out during January to April 2008, as part of the first national survey of the Scottish crossbill (Summers and Buckland, 2011) within *c.* 3500 km^2 of conifer woodland in mainland Scotland north of 56°50′N (*i.e.* within the main range of the Scottish crossbill; Summers et al., 2004).

The sampling design was based on 1-km Ordnance Survey grid squares that had conifer woodland at their centre, as defined by the 1999 National Inventory of Woodland and Trees (NIWT) (Forestry Commission, 1999). Every fourth square was selected for survey, providing 889 points, of which 34 were excluded because they had no conifers within 50 m. Also, three points were not visited, leaving 852 survey points (Fig. 1) (Summers and Buckland, 2011).

The survey involved a single visit to the centre of each 1-km square where a crossbill excitement call was played from a compact disc player for at least ten minutes in the four cardinal directions from each survey point (2.5 min per direction). The exact positions of survey points were adjusted so that the observers stood in open spaces (rides *etc.*) rather than dense woodland in order to observe in-flying birds. To identify crossbill species, tape recordings of the calls were made and birds identified from sonograms (Summers et al., 2002; Summers and Buckland, 2011). No attempt was made to identify crossbills from the small differences in morphology (Knox, 1990a).

In order to relate crossbill presence/absence to habitat characteristics, the percentage cover of the different conifer species and the stand structures were determined from a sketch map of the area within 50 m of each survey point (0.8 ha). Observers also noted the presence/absence of cones on trees for each conifer species at the sample points. However, for those species that retain cones for many years (lodgepole pine and larches), it was difficult to be sure that cones from the current cohort were present, though there may have been residual seeds from previous cohorts. Conifer heights for each species and stand were allotted to the following five bands: less than 1 m, 1–5 m, 5–10 m, 10–15 m and over 15 m. Tree spacing was allotted to three bands: less than 2 m, 2–5 m and over 5 m. For analysis, a height index was obtained by multiplying the percentage cover for 1–5 m conifers by one, 5–10 m by two, 10–15 m by three and over 15 m by four. These four values were then added together. Trees less than 1 m high were ignored. A similar density index was obtained by combining the percentage cover of the three spacing bands, each weighted according to their spacing.

To describe the conifer species composition from a larger area of woodland, from which the crossbills were drawn, stock maps from the Forestry Commission's compartment data base were analysed. These provided areas of different tree species and their planting years within 25 ha around the sample points. This area was close to the effective sampling area for crossbills (21 ha, Summers and Buckland, 2011) and is the approximate foraging range for crossbills during the breeding season (RSPB unpubl. data). These subcompartment data were available for land only in Forestry Commission ownership and referred to 429 of the survey points (Fig. 1). Only plantings before 1997 were included, thus excluding conifers that were probably not coning (Gordon and Faulkner, 1992).

The 2002 NIWT was used to obtain landscape parameters within 25 ha of the sample points: distance to the nearest conifer woodland edge, area of woodland and length of conifer woodland edge. Woodland edge was defined as the boundary, if it was greater than 50 m from another conifer woodland boundary in a perpendicular line from that boundary. A fragmentation score was determined by dividing the length of conifer woodland edge by the area of conifers in the sample.

Given that crossbills feed on the seeds from conifer cones (Benkman, 1987), stand use depends partly on the cone crop sizes of the different species (Reinikainen, 1937). In addition to noting the presence of cones during the survey of the crossbills, information on cone abundance was obtained from the Forest Research's Forest Condition Monitoring (FCM) programme (Broome et al., 2007). At sites across northern Scotland (10 for Norway spruce, 14 for Sitka spruce, 18 for Scots pine, 40 for lodgepole pine and 20 for larches, Fig. 1), trained surveyors used a 4-point score (0 – zero, 1 – few, 2 – many and 3 – abundant) to assess the current

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