Global Ecology and Conservation 4 (2015) 380–387

Contents lists available at ScienceDirect

Global Ecology and Conservation

journal homepage: www.elsevier.com/locate/gecco

Original research article

Diversity and distribution of epiphytic bryophytes on Bramley's Seedling trees in East of England apple orchards

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HIGHLIGHTS

- The epiphytic bryophyte flora of four UK bramley orchards was surveyed.
- Tree size and shape account for around 10% of the variation in the bryophyte flora.
- Orchard management can impact diversity and distribution of epiphytic bryophytes.

ARTICLE INFO

Article history:
Received 5 March 2015
Received in revised form 30 July 2015
Accepted 31 July 2015
Available online 28 August 2015

Keywords:
Epiphyte
Bryophyte
Orchard biodiversity

ABSTRACT

Epiphytic bryophytes on apple trees were investigated in relation to a selection of tree characteristics. Management of orchard trees for fruit production affects the habitats available for colonisation and growth of epiphytes on trunks and branches. Bryophytes recorded on Bramley's Seedling apple trees in orchards in Hertfordshire and Cambridgeshire showed a high level of similarity in species composition between the orchards. The similarity between orchards was, however, much reduced when relative species cover on the trees was taken into account. Twenty three species were recorded on the 71 trees sampled for detailed investigation. Tree structure, as determined by management, explained about 10% of the observed variation in bryophyte cover. Within that, trunk girth and distance to nearest neighbouring orchard trees were the most important factors. This information is of value to orchard managers aiming to become more proactive in managing their habitats for the benefit of biodiversity.

1. Introduction

Epiphytic lichens and bryophytes are often studied as useful indicators of habitat quality, both in relation to air quality (Davies et al., 2007) and, for example, in considering woodland and forest planting (Hazell et al., 1998). This was the case especially in relation to industrial pollution and subsequent improvements in air quality following controls on pollutant emissions. In the south and east of England, for example, studies by Bates et al. (1997, 2004) focussed on bryophytes growing on standard trees along roadsides and at woodland edges. Smith (1982) reviewed the relationships between epiphytic bryophytes and some tree characteristics, including structure and bark chemistry. Very little was published on orchards, however, until Stevenson and Rowntree (2009) suggested that the planting and management of orchard trees can provide a readily sampled habitat for comparing single species and single variety studies of diversity and abundance of epiphytic bryophytes. Orchards, groups of fruit trees planted for food production, have, and continue to be, an economically important

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http://dx.doi.org/10.1016/j.gecco.2015.07.014

Table 1
Location and features of orchards.

Orchard	Location	Approx planting date	Tree structure
Oaklands College	St Albans, Hertfordshire	1980	Young half standard
St Elizabeth's	Much Hadham, Hertfordshire	1930	Bush/half-standard
Tewin	Tewin, Hertfordshire	1930	Bush
Aldreth 70	Haddenham, Cambridgeshire	1930	Half standard
Aldreth 100	Haddenham, Cambridgeshire	1900	Half standard

part of the British landscape. However, in recent times fruit has been sourced from elsewhere and many orchards have fallen into disrepair or been removed altogether (Robertson and Wedge, 2008). It is estimated that there has been a 63% reduction in the area of England given over to orchards since the 1950s (NE, 2008). Although there has been a recent small increase in commercial orchards (Defra, 2013) overall, loss of orchard habitat is still considerable and on-going (Burrough and Robertson, 2008; Burrough et al., 2010) Traditional Orchards are identified as a priority habitat in the UK Post 2010 Biodiversity Framework due to the high level of biodiversity they can support. Fruit trees are the main feature of orchard habitats and these have been found to host a high diversity of epiphytes, particularly bryophytes and lichens (Lush et al., 2009; Robertson et al., 2012; Stevenson and Rowntree, 2009).

This study aimed to record epiphytic bryophyte diversity in a selection of apple orchards in the East of England and to identify aspects of the management of the habitats that were important in contributing to epiphytic bryophyte diversity and abundance. By identifying variables which are under the control of orchard owners is hoped that the insights can be used to aid orchard owners in becoming more proactive in managing their habitats for the benefit of biodiversity.

2. Methods

2.1. Site selection and descriptions

Suitable survey sites were identified through contacts with local individuals, the Hertfordshire Biological Records Centre and the Hertfordshire Orchard Initiative.

Four sites, three in Hertfordshire and one in Cambridgeshire (consisting of two different aged orchards), were selected for surveys (Table 1) between 2009 and 2011 and a total of 71 trees were sampled. The surveys were restricted to a single variety, Bramley's Seedling, the most common single variety of cooking apple (*Malus domestica*) grown in the UK (Defra, 2013). The orchards differed in age with the youngest having been planted in 1980 and, apart from Aldreth 100, contained mixed varieties. The oldest orchard (Aldreth 100) was planted over 100 years ago but the exact date of planting was not known. Species accumulation curves showed that 10 trees of the same variety within an orchard were sufficient to represent the orchard and a random number generator was used to select these. The position of each tree surveyed was recorded using GPS.

Bryophytes were identified following Atherton et al. (2010) and Smith (2004). No subspecies were recorded and it was not possible to distinguish between the frequently infertile *Ulota crispa* and *Ulota bruchii* in the field.

2.2. Survey methods

All bryophytes on the trunks and branches of the trees were recorded up to a height of around 2 m. Any bryophytes growing higher than this were not identified but were included in estimates of total bryophyte cover.

To record bryophyte cover a visual estimate of the area covered by each species was made using a 4 cm^2 grid as a reference. Area was recorded as multiples of this reference area. Although it is generally acknowledged that visual estimates are not the best method for measuring plant cover the irregular nature of the epiphytic flora and the structure of the trees themselves made other methods, such as the pin-point or point-intercept method (Kershaw and Looney, 1985) difficult to implement.

Five tree characteristics were measured: tree height, estimated using an abney level; trunk height; trunk girth; canopy area calculated using the equation for the area of an ellipse; and distance to nearest orchard tree. An Extech pH100 flat headed pH meter (EIC, 2010) was used to record bark pH. Three separate areas of bark, on primary branches free of epiphytes, were dampened with a 1M solution of potassium chloride and the pH was recorded when the reading had stabilised for 10 s.

2.3. Data transformations and analysis

Bark pH values for each tree were calculated from H^+ ion concentration using the equation $H^+ = 10^{-pH}$, using the mean value from the three readings. This value was then converted back to pH units ($pH = -\log_{10}(H^+)$).

One-way analysis of variance (ANOVA) and post-hoc test Tukey's pairwise comparisons were undertaken using the free data analysis package Paleontological Statistics (PAST) version 2.14 (Hammer, 1999). Sørensen Similarity indices, Bray-Curtis similarity indices, Analysis of similarity (ANOSIM), Similarity percentages (SIMPER) and Detrended Correspondence Analysis (DCA) were carried out using CAP3 (Seaby and Henderson, 2007), Pearson correlations with scattergraphs and Canonical correspondence analysis (CCA) were carried out using ECON (PISCES, 2007).