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Ecological and spatial drivers of population synchrony in bird assemblages

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Abstract

Spatial population synchrony is defined as the coincidental changes of population density or other demographic parameters over time. Synchrony between local populations is believed to be widespread in nature because it has been found across a range of ecological guilds and across large spatial scales. However, a detailed understanding is still lacking of the extent of synchronous patterns in population parameters across animal communities, and of the relative importance of the several potential causes of population synchrony.

This study aimed to contribute to the understanding of how widespread spatial synchrony is in bird communities and to identify the main ecological drivers of synchrony. To achieve this we examined patterns of synchrony among bird populations inhabiting two contrasting areas of southeast Australia: the Victoria Central Highlands and Booderee National Park. Bird populations were studied through yearly point counts spanning 2004–2012 in Victoria and 2003–2012 in Booderee National Park.

Our empirical assessment showed that spatial proximity, synchrony in weather (cumulative rainfall) and habitat type influenced the level of spatial synchrony in 11 out of the 38 species examined (i.e. 29% of the species). Synchrony was primarily driven by spatial proximity, followed by synchrony in rainfall; habitat similarity played a small role as driver of synchrony in both areas.

Zusammenfassung

Räumliche Synchronität von Populationen ist definiert als das zeitliche Zusammenfallen von Änderungen der Populationsdichte oder anderer demographischer Parameter. Synchronität zwischen lokalen Populationen gilt als in der Natur weit verbreitet, denn sie wurde bei einer Reihe von ökologischen Gilden und über weite räumliche Skalen gefunden. Indessen mangelt es immer noch an detaillierten Kenntnissen zum Ausmaß synchroner Muster bei den Populationsparametern vieler Tiergemeinschaften und zur relativen Bedeutung der vielen potentiellen Ursachen für Synchronität. Ziel unserer Studie war es, einen Beitrag zum Verständnis davon zu leisten, wie weit verbreitet räumliche Synchronität bei Vogelgemeinschaften ist, sowie die wichtigsten bestimmenden Faktoren der Synchronität zu identifizieren. Hierzu untersuchten wir Synchronitätsmuster von Vogelpopulationen, die zwei unterschiedliche Gebiete Südostaustraliens bewohnen: das Hochland von Zentral-Viktoria und den Booderee-Nationalpark.

Die Vogelpopulationen wurden mit jährlichen point counts erfasst, von 2004-2012 in Victoria und von 2003 bis 2012 im Booderee-Nationalpark. Unsere Analysen zeigten, dass räumliche Nähe, Synchronität des Wetters (kumulativer Niederschlag)

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und Habitattyp den Grad der räumlichen Synchronität bei 11 von 38 untersuchten Arten (d.h. 29%) beeinflusste. Die Synchronität wurde hauptsächlich durch räumliche Nähe gesteuert, danach durch Synchronität der Niederschläge. Ähnlichkeit des Habitats spielte in beiden Gebieten eine geringe Rolle als Steuergröße der Synchronität.

Keywords: Synchronic; Abundance; Weather; Growth rate; Bird surveys; Synchronising agents; Dispersal

Introduction

Spatial population synchrony is defined as the coincidental changes of population density or other demographic parameters over time (Bjørnstad, Ims, & Lambin 1999; Liebhold, Koenig, & Bjørnstad 2004). Synchrony between local populations is believed to be a pervasive phenomenon because it has been found across a range of ecological guilds, in many taxa, and across large spatial scales (e.g. thousands of kilometres; Koenig 2002; Liebhold et al. 2004). Synchrony among populations arises mainly through two classes of mechanisms: climate which acts over broad scales (Ranta, Kaitala, Lindström, & Helle 1997; Koenig 2002) – and dispersal – a more local effect caused by individuals dispersing between neighbouring populations (Ripa 2000; Peltonen, Liebhold, Bjørnstad, & Williams 2002). Recent application of advanced statistical modelling to long-term large-scale datasets on population dynamics has helped to increase our understanding of spatial and ecological drivers of population synchrony (e.g. Gouhier, Guichard, & Menge 2010; Haynes, Bjørnstad, Allstadt, & Liebhold 2013). However, we still lack a detailed understanding of the prevalence of synchronous patterns across animal communities, and of the relative importance of the several potential causes of population synchrony (Liebhold et al. 2004).

Several issues have hampered a detailed understanding of patterns of spatial synchrony, in particular: (a) *The lack of data*. The study of synchrony requires large-scale datasets encompassing several years. (b) *Restricted taxonomic scope*. Synchrony is often studied in single species or small portions of the community (e.g. Bellamy, Rothery, & Hinsley 2003). (c) *Sampling bias*. Observer and sampling variability may mask or bias patterns of synchrony (Thomas 1991), leading to underestimation of the nature and extent of synchrony.

In this paper, we present a study designed to explore patterns of synchrony in the abundance of bird populations inhabiting two contrasting areas of south-eastern Australia: the Victoria Central Highlands (VCH), an area characterised by continuous areas of tall wet *Eucalyptus* forest belonging to several different forest types; and Booderee National Park (BNP), an extremely heterogeneous coastal area characterised by highly contrasting vegetation types. Both areas support species-rich bird assemblages (77 species recorded in VCH and 128 in BNP) consisting of a variety of ecological guilds, ranging from consumers of nectar to insectivores.

Our study was developed around two broad and exploratory questions:

How widespread is synchrony in bird communities?

We tested for spatial synchrony among the most frequently recorded birds occurring in the study areas (22 species in VCH and 30 in BNP). We expected relatively high levels of synchrony due to the relatively high level of connectivity existing in both areas (Powney, Broaders, & Oliver 2012) and due to the relatively high dispersal capabilities of many species of birds (Paradis, Baillie, Sutherland, & Gregory 1999). However, we predicted that synchrony would be lower in BNP due to the high levels of vegetation heterogeneity (e.g. different vegetation types characterised by different bird communities, Appendix A: Tables 1 and 2).

Which are the main drivers of spatial synchrony in bird populations?

At the scale considered here (3281 km^2 VCH and 110 km^2 BNP), dispersal should be expected to prevail over weather factors because differences in weather should be small and dispersal between local populations should be high (Lande, Engen, & Sæther 1999; Kendall, Bjørnstad, Bascompte, Keitt, & Fagan 2000). We also expected that habitat type would play a major role in determining synchrony in the highly heterogeneous BNP due to reduced connectivity between local populations (Bellamy et al. 2003; Powney, Roy, Chapman, Brereton, & Oliver 2011).

Materials and methods

Study areas

The Victoria Central Highlands region (Fig. 1) lies approximately 120 km north-east of Melbourne (coordinates 37°20′–37°55′S and 145°30′–146°20′E, altitudinal range: 303–1225 m asl; area covered by convex polygon encompassing sites: 3281 km^2) and is characterised by mild, humid winters with occasional periods of snow. The study area consists mainly of Mountain ash (*Eucalyptus regnans*), Alpine ash (*Eucalyptus delegatensis*) and eucalypt forest (Appendix A: Table 1).

Booderee National Park (Fig. 1) is located ∼200 km south of Sydney on the southern coast of New South Wales (coordinates 35°7′–35°11′S and 150°45′–150°35′ES, altitudinal