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Can wetlands maintained for human use also help conserve biodiversity? Landscape-scale patterns of bird use of wetlands in an agricultural landscape in north India

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ABSTRACT

Wetlands in tropical agricultural landscapes are maintained largely by local institutions explicitly for human use, which is assumed to deter biodiversity. Conservation efforts have been biased towards protecting large wetlands that are assumed to be adequate to conserve the majority of species of focal taxa, usually birds. These assumptions remain untested, and landscape-scale conservation planning for wetlands is largely absent, as is a generalised understanding of wetland use by focal taxa. We designed a landscape-scale survey to understand patterns and processes determining beta diversity of birds using agricultural wetlands in south-western Uttar Pradesh, India where wetlands have experienced prolonged and intensive human use for several centuries. Observed bird species richness (99 species in 28 wetlands) is the highest known for any agricultural landscape in south Asia signifying that even intensive human use of wetlands does not necessarily deter their ability to retain biodiversity. Birds exhibited strong scale dependent wetland use underscoring the need to conserve wetlands of varying sizes and at varying densities on the landscape. Beta diversity was due largely to species turnover (0.877) with minimal effect due to nestedness (0.055) suggesting that conserving a few large wetlands will not adequately meet goals of conserving the majority of wetland bird species. Prevailing assumptions regarding biodiversity conservation in tropical agricultural wetlands require being revised, and a landscape-scale approach that incorporates ecological realities is needed. Incorporating local institutions alongside formal protectionist methods offer a potential win–win situation to maximise conservation of biodiversity in tropical agricultural wetlands.

1. Introduction

Inland wetlands amid croplands, or agricultural wetlands (not including croplands such as flooded rice paddies, but only discrete wetlands recognised as lakes, ponds, and oxbow lakes), tend to be small and isolated but can provide a range of ecological services such as groundwater recharge, and also ensure the preservation of biodiversity (Semlitsch and Bodie, 1998; Leibowitz, 2003). Scientific attention on agricultural wetlands has been minimal, and practically all the attention has been on wetlands located in temperate regions (Finlayson and Spiers, 1999; Zedler and Kercher, 2005). The vast majority of studies have focused on wetlands that are maintained on the landscape as part of national networks of protected areas or via payments to farmers (Davies et al., 2009; Thiere et al., 2009; Fennessey and Craft, 2011). Biodiversity conservation and ecological services, particularly water retention for agriculture, are the primary impetus to conserving the majority of these wetlands. Human use of these wetlands is either limited or absent to help maximise conservation of focal taxa and to improve water quality (Zedler and Kercher, 2005; Fennessey and Craft, 2011).

The situation in most tropical countries that have much higher human densities and species richness is starkly differently. The majority of freshwater inland wetlands in the tropics are agricultural wetlands which experience intensive, sustained, and multiple human uses including cattle grazing, harvest of multiple wetland products (e.g. reeds, fish, silt), and water for agricultural and domestic purposes (Adger and Luttrell, 2000; Silvius et al., 2000; Dixon and Wood, 2003; Gopal, 2005; personal observations). A miniscule proportion of such wetlands are protected for biodiversity conservation in most tropical countries, and there is growing interest in enhancing persistence of agricultural wetlands for their various ecological services, including as habitat for biodiversity conservation (Zedler and Kercher, 2005; Brander et al., 2006;

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Verhoeven and Setter, 2010). It is widely assumed that removal of human use from wetlands is necessary to maximise biodiversity conservation (Gopal, 1999; Middleton, 2013). Increasing attention is being directed at ascertaining the value of large wetlands already assumed to be important, and towards wetlands that are part of national protected area networks. As a result, an unbiased understanding of how agricultural wetlands in general may be contributing towards conserving and maintaining biodiversity is missing.

Landscape-scale effects have been documented for several taxa species that use agricultural wetlands. It is becoming increasingly evident that landscape-scale characteristics interact with site-level habitat characteristics to affect species densities and life histories (Naugle et al., 1999; Albanese and Davis, 2013). Additionally, the value of understanding processes contributing to landscape-scale diversity, or β-diversity, of focal taxa is gaining in importance, especially since this understanding can aid in conservation planning greatly (Paracuellos, 2006; Baselga, 2010). The two processes that drive β-diversity are nestedness and species turnover (Baselga, 2010). Nestedness occurs when the full complement of species are found in few sites on the landscape, with assemblages in other sites being subsets of the ones found in the few sites. Alternatively, landscapes where species turnover is dominant has sites with dissimilar species assemblages requiring a large number of sites to ensure that the full complement of species is accounted for. If nestedness is dominant, efficient conservation can be achieved by identification and protection of the few sites to ensure that at least some populations of all species are conserved. Conversely, if species turnover is the dominant process, effective conservation for the full complement of species of the focal taxa can be achieved only by retaining a large number of sites on the landscape (see Baselga, 2010). Landscape-scale understanding of patterns and processes driving wetland use by taxa can therefore be invaluable to help plan wetland conservation, but is rare in most regions of the world.

The lack of attention to wetland ecology is readily apparent in south Asia (Dudgeon, 2003; Zedler and Kercher, 2005). This region has among the highest human densities in the world with also the highest level of agricultural intensification spanning several centuries (Ellis et al., 2010). Despite these pressures, a relatively large number of agricultural wetlands remain as flooded natural depressions as well as water storage structures maintained for irrigation (Space Application Centre, 2010; Panigrahy et al., 2012). Wetlands are maintained here as part of a long-standing tradition explicitly for human use (Ambastha et al., 2007; Sundar, 2011). Growing demand for drained agricultural land has lead to widespread illegal conversions of wetlands, but strong dependence on wetland resources (e.g. for grazing, cattle collection of wetland products such as lotus stems for food) have prompted farmers to acquire legal grounds for their preservation as common lands (Singh, J. versus State of Punjab, 2011). An understanding of ecological values of these wetlands, however, has been minimal. Even basic aspects such as mapping using robust, repeatable methods have been achieved relatively recently (Space Application Centre, 2010; Panigrahy et al., 2012). Wetland conservation focuses on single, large wetland sites with large number of wintering waterfowl, and discussions on landscape-scale approaches are negligible (Ambastha et al., 2007; Nagabhatla et al., 2010). Conservation discussions also continue to repeat assumptions regarding the deterrence of biodiversity due to human use. Converting a large number of common use wetlands to reserves seems practically implausible given the millions of people currently dependent on the wetlands, and the costs involved in acquiring so much land. In addition, conversions of common use wetlands to reserves is seldom without political consequences, and reserves experience significant ecological changes that do not always fulfill the goals of species conservation (Gopal, 1999; Lewis, 2003). Additionally, the focus is entirely on conserving large wetlands with the implicit assumption that this approach will conserve the majority of focal wetland species (Nagabhatla et al., 2010; Space Application Centre, 2010). This approach assumes therefore that β-diversity follows a strong nested pattern, but it is not known if this is indeed the case. Can wetlands maintained explicitly for human use, and experiencing intensive, sustained use also be useful for biodiversity conservation, and are there landscape-scale patterns of wetland use by focal taxa that require consideration while considering agricultural wetlands as repositories for biodiversity?

To answer these questions we conducted a landscape-scale study of winter wetland use by birds in seven districts of south-western Uttar Pradesh in the Gangetic flood-plains focusing on wetlands not protected as bird reserves. This region is listed as an internationally important landscape for wetland birds (BirdLife International, 2003), but surveys of wetland use by birds using robust field designs are absent. Recent work focusing on the landscape as a whole has documented persistence of a surprisingly high bird diversity, including the majority of the global populations of several bird species of global conservation concern (Sundar, 2011; Sundar and Kittur, 2012). The seven districts have >10,000 persisting wetlands of vastly varying sizes (see Section 2), of which only four are protected as bird sanctuaries (R. De, Uttar Pradesh Forest Department, pers. comm.). Wetland distribution is irregular varying spatially in extent and density (Fig. 1c and d) providing an excellent opportunity to assess if bird use of wetlands varies due to these two landscape-scale metrics of wetland distribution. In this study, we specifically assess: (i) whether birds exhibit variation in wetland use due to two landscape-scale metrics (size and density) of wetland distribution (or scale dependent wetland use), and (ii) the dominant processes determining β-diversity of birds (nestedness or species turnover) using these agricultural wetlands.

2. Methods

2.1. Study area

South-western Uttar Pradesh is located in the north Indian Gangetic floodplains, and has been almost entirely converted to non-woody cereal agriculture for at least three centuries with human population densities currently ranging from 500 to 3000 people km^2 (Ellis et al., 2010). Agricultural wetlands comprise <1% of the landscape with the majority being small and isolated (Anonymous, 2007). The primary crops here are rice during the rainy season or monsoon (June–October) and wheat during the winter (November–February), with fields largely left fallow during the summer. We focused on seven districts in south-western Uttar Pradesh bounded by the Ganges and Yamuna rivers (Fig. 1a and b). Monsoonal rainfall in 2012 was delayed starting in mid-August against the normal start in July. Also, the total volume of rainfall (460 mm) was well below normal in south-west Uttar Pradesh (annual mean for 2000–2009: 1300 mm; District Magistrate Office, Etawah, pers. comm.). The survey therefore assessed wetland use by birds during a below-normal rainfall year when the landscape was water stressed. Additional details of land use and bird diversity on the landscape are available elsewhere (Sundar, 2011; Sundar and Kittur, 2012).

Our personal observations have shown that wetlands experience year-round use by people. The most common uses included grazing a variety of livestock (cattle, pigs, sheep, goat), water extraction for domestic and agricultural use, harvest of several natural resources including vegetation and aquatic fauna, removal of dried soil in the summer to strengthen walls and agricultural dykes, cultivation of water chestnut in the monsoon, and illegal hunting of waterfowl using both guns and poisons. The over-