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Importance of Ethiopian shade coffee farms for forest bird conservation

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ABSTRACT

Coffee is the most important tropical commodity and is grown in high-priority areas for biological conservation. There is abundant literature on the conservation value of coffee farms internationally, but there has been little research on this topic in Africa. Ethiopia is a diverse and little-studied country with high levels of avian endemism, pressing conservation challenges, and where *Coffea arabica* originated. We sampled bird communities in shade coffee farms and moist evergreen Afromontane forest in Ethiopia utilizing standard mist netting procedures at seven sites over three years to evaluate bird species richness, diversity and community structure. Although species diversity did not differ between shade coffee and forest, shade coffee farms had over double the species richness of forest sites and all but one of the nine Palearctic migratory species were captured only in shade coffee. There was a greater relative abundance of forest specialists and understory insectivores in forest, demonstrating that little-disturbed forest is critical for sustaining these at-risk groups of birds. Nonetheless, all species recorded in primary forest control sites were also recorded in shade coffee, indicating that Ethiopian shade coffee is perhaps the most "bird-friendly" coffee in the world. This is an important finding for efforts to conserve forest birds in Africa, and for shade coffee farmers that may benefit from avian pest regulation and biodiversity-friendly coffee certifications.

1. Introduction

1.1. Tropical forest declines and implications for bird populations

Increasing human populations and corresponding land use changes are driving a global extinction crisis (Brashares et al., 2001; Pimm et al., 2006; Vitousek et al., 1997). Tropical forests are the most species-rich terrestrial ecosystem on Earth, supporting up to 70% of plant and animal species, and are being lost at an alarming rate (Dirzo and Raven, 2003; Donald, 2004; Laurance and Bierregaard, 1997; Sodhi et al., 2004). In the last decade, approximately 13 million hectares of forest were cut down each year, with most of the losses occurring in the tropics (UNFAO, 2010). Tropical deforestation represents the single greatest threat to global biodiversity (Donald, 2004): it results in rapid transformations in plant and animal communities, which drastically alters ecological processes and impacts human societies (Clough et al., 2009a; Tilman et al., 2001).

Numerous studies attribute forest bird declines to deforestation and the conversion of tropical forests to agricultural habitats, particularly in forest archipelagos in agricultural landscapes (Bregman et al., 2014; Newmark, 1991; Şekercioğlu, 2012a; Sigel et al., 2006; Sodhi et al., 2011; Stratford and Stouffer, 1999). Currently, 23% of bird species are globally threatened or near threatened with extinction (BirdLife International, 2014), with the vast majority of threatened species inhabiting tropical forests (BirdLife International, 2014; Brooks et al., 1999; Lees and Peres, 2006; Sodhi et al., 2004; Turner, 1996).

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Understanding the ecological drivers underlying avian distributions is critical to evaluate the overall ecological integrity of ecosystems because birds are highly specialized, occupy a variety of ecological niches, have key ecological functions, and are variably susceptible to disturbance (Komar, 2006; Şekercioğlu, 2006a, 2006b; Anjos et al., 2015; Pollock et al., 2014; Pavlacky et al., 2014). Bird extinction risk increases with ecological specialization (Şekercioğlu, 2011). Shifts in bird relative abundance and/or local extinctions are likely to affect ecological processes, including seed dispersal, pollination, nutrient cycling, and even soil formation (Chapin et al., 1998; Heine and Speir, 1989; Lens et al., 2002; Şekercioğlu et al., in press).

Forest understory insectivores are especially sensitive to forest fragmentation and disturbance, and are thus among the most threatened bird species in the world (Tobias et al., 2013). They have relatively high habitat specificity, dependence on forest interior habitats, and limited mobility (Lens et al., 2002; Şekercioğlu et al., 2002; Tobias et al., 2013). Evaluating where and why they are declining is a conservation priority in the tropics (Tobias et al., 2013).

1.2. Agroforests as bird habitat

Preserving biodiversity in habitats that are impacted by human activities is important because (i) these habitats make up an increasingly large portion of the globe (Norris, 2008) and (ii) about one third of the world's ~10,000 bird species have been recorded in human-dominated and mostly agricultural habitats (Şekercioğlu et al., 2007). Agriculture accounts for over 37% of global land cover (World Bank, 2012a) and is a major cause of deforestation. Agroforestry—a farming technique that combines a mixture of trees, shrubs, and crops—is particularly valuable for biodiversity conservation, especially when native tree species are present (Fischer and Lindenmayer, 2007; Perfecto et al., 1996; Pimentel et al., 1992). The conservation value of tropical agroforests is being increasingly recognized (Greenberg et al., 2008; Perfecto and Vandermeer, 2008; Tscharntke and Klein, 2005). Landscape management strategies that maximize biological diversity retention, ecological services, and economic profitability should be investigated and promoted (Bengtsson et al., 2005; Railsback and Johnson, 2014; Rosenzweig, 2003).

A number of factors affect bird assemblages in tropical agroforests, including forest patch size, proximity to other habitat types, percent canopy cover, and shade tree composition. For example, agroforests that have intact forest canopies with high shade tree diversity and native tree species harbor relatively high avian diversity (Gove et al., 2008; Perfecto et al., 1996; Greenberg et al., 1997; Van Bael et al., 2007). Shade coffee is among the most bird-friendly of agricultural habitats, often harboring a high diversity of birds, including forest specialists (Komar, 2006; Perfecto et al., 1996; Greenberg et al., 1997; Van Bael et al., 2007). However, most avian studies only evaluate species diversity or richness, and often overlook the role of community composition in shaping the ecological and conservation importance of bird species utilizing coffee farms. In particular, there is a need to evaluate the degree of habitat specialization, foraging guild structure, and conservation status of bird communities (Komar, 2006). Furthermore, the majority of this research has taken place in the Neotropics and the ecology of birds in coffee farms in Africa, in particular, needs further investigation (Komar, 2006; Şekercioğlu, 2012a).

1.3. Ethiopia: Importance and challenges

Ethiopia is a unique, immensely diverse and little-studied country with a high level of avian endemism. It is located along the critical African-Eurasian migratory flyway (Ash et al., 2009; Şekercioğlu, 2012b). Eastern Afromontane and Horn of Africa Global Biodiversity Hotspots cover most of the country (Conservation International, 2014) and the Ethiopian highlands account for over 50% of the Eastern Afromontane eco-region (Fig. A1). This eco-region is intermittently distributed, is the least explored and least protected eco-region in Africa, and is a major source of endemism (Gole et al., 2008; Küper et al., 2004; Scholes et al., 2006). Approximately three-quarters of plant species (Gole et al., 2008) and 32 bird species are endemic to the Abyssinian Highlands, which include Ethiopia and a portion of neighboring Eritrea (Ash et al., 2009). Despite minimal visitation by ornithologists and birders, especially the unstable border regions with Somalia, Kenya, North and South Sudan, and Eritrea, an impressive total of over 860 species have been documented (Şekercioğlu, 2012b); ranking Ethiopia among the richest countries in the world in terms of bird diversity. This species list is steadily growing with increasing research and tourism. The combination of bird diversity, endemism, globally important migration routes, and scant research make Ethiopia a top priority in Africa for ornithological research and conservation (Şekercioğlu, 2012b).

While Ethiopia has a tremendous wealth of natural resources and biological diversity, it also faces serious conservation challenges. The country's population growth rate is among the highest in the world—currently estimated at 2.6% per year (World Bank, 2013)—which is causing rapid and widespread conversion of forest habitats for human settlements, charcoal and firewood harvesting, and clearing for agriculture, including tea and coffee plantations (Bekele, 2011; Campbell, 1991; Hurni, 1988). Furthermore, there is limited governmental commitment to wild-land conservation. These factors have led to widespread deforestation in the biologically rich Ethiopian highlands: forest cover was reduced from over 15,100,000 ha in 1990 to just under 12,300,000 ha in 2010—a drastic 18.6% decline in 20 years (FAO, 2010).

Global coffee consumption has increased consistently since the early 1980s, at a rate of about 1.2% annually (ICO, 2012a). With an annual value of $100 billion (Donald, 2004), coffee is the second most valuable legal international commodity after oil (O'Brien and Kinnaird, 2003) and is the most important export commodity for many tropical countries (ICO, 2012a). It is produced on approximately 11.5 million hectares of terrain, often in areas of high conservation importance (Donald, 2004). *Coffea arabica*—the most widespread and economically valuable coffee strain—makes up two-thirds of the world's coffee market (Aerts et al., 2011; Labouisse et al., 2008), and is native to southwestern Ethiopia where it has been cultivated for over a thousand years (Aerts et al., 2013; Anthony et al., 2001, 2002).

The agricultural industry accounts for 80% of employment in Ethiopia (United Nations, 2012) and coffee is the primary export crop (ICO, 2012b). From 2000 to 2010, coffee accounted for an average of 33% of export earnings, the second most of any country (ICO, 2012b). Present day coffee cultivation in Ethiopia ranges from the harvesting of near-wild coffee in forest to shade coffee farms with native tree canopies to monoculture sun coffee farms. While Ethiopia has a long history of shade coffee farming, it is following a recent global trend towards sun coffee production, due to the ease of mechanization which can yield higher production per unit area despite decreased production per plant (Donald, 2004; Gove et al., 2008). Intensive sun coffee farms produce a lower quality crop and often face problems with crop pollination and pest outbreaks due to loss of avian ecological function (Kellermann et al., 2008). These biodiversity losses can cause increased reliance on pesticides, which in turn cause further ecological damage (Donald, 2004). As little forest cover remains in Ethiopia and agriculture is the dominant land use, determining the conservation value of agricultural systems is pressing. In addition to being an important step towards determining avian conservation priorities