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OVERVIEW

SHADE COFFEE: A GOOD BREW EVEN IN SMALL DOSES

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MIGRANT BIRDS capture our imagination like few other natural phenomena because of their prodigious physiological and navigational capabilities and the sheer multitude of species and individuals involved. As impressive as migration is, it faces threats from humans via habitat deterioration and loss (Terborgh 1989, Sherry and Holmes 1995). The mechanisms underlying population declines—or worse, extinctions—of migrants often are well known. In particular, edge effects associated with habitat fragmentation reduce fecundity of birds in many wooded North American breeding habitats. Reproductive success suffers where edge-loving nest predators and brood-parasites such as Brown-headed Cowbirds (*Molothrus ater*) accumulate (Wilcove 1985, Robinson et al. 1995, Askins 1999) and where food abundance declines (Burke and Nol 1998). In the tropical wintering grounds, habitat conversion and forest loss also are implicated as major causes of population problems for migrants (Robbins et al. 1989, Rappole and McDonald 1994, Sherry and Holmes 1996). However, the mechanisms by which migratory birds respond to tropical habitats are poorly known, and we lack information on how habitat fragmentation affects migratory birds wintering in the tropics.

In this issue of *The Auk,* Wunderle and Latta (2000) provide one of the first studies of how habitat fragmentation influences wintering migrants. Shade coffee plantations provided a handy choice for this study because they comprise some of the only remaining mid-elevation habitat for forest-adapted birds in many parts of the northern Neotropics, and they tend to be structurally and floristically homogeneous. These cultivated woodlands typically swim in a sea of pasture, human residences, and non-shaded agricultural lands—the kinds of habitats associated with deleterious edge effects in temperate breeding areas. Shade coffee plantations often sustain wildlife as abundant and diverse as most tropical forests (e.g. Perfecto et al. 1996; Greenberg et al. 1997 a, b; Wunderle and Latta 1998). Wunderle's and Latta's (2000) second purpose was to ask why shade coffee is so popular with migrants.

To look at fragmentation effects, Wunderle and Latta (2000) sampled 14 small shade coffee plantations (0.1 to 8.7 ha) in the Dominican Republic, focusing on three of the most abundant Caribbean wintering migrants as ''replicates'': American Redstart (*Setophaga ruticilla*), Black-and-white Warbler (*Mniotilta varia*), and Black-throated Blue Warbler (*Dendroica caerulescens*). Bird responses examined included persistence in a fragment for varying time periods up to a year postcapture, sex ratio, and body condition, all in response to fragment area and circumference, vegetation composition and structure, and the nature of the surrounding matrix. Results indicated that fragmentation affected these three species little, even in plantations that were smaller than typical winter home ranges (0.4 to 1.0 ha). For example, the frequen-

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cy of wanderers (individuals never resighted after initial capture) varied independently of fragment size in all three species. None of the species exhibited changes in sex ratio with fragment size. Sex ratio of American Redstarts and Black-throated Blue Warblers favored males (82% and 78% of birds, respectively), which suggests that shade coffee plantations provide high-quality habitat, based on the assumption that male-dominated habitats generally are superior for these birds (Wunderle 1992, Marra and Holberton 1998, Marra et al. 1998). Furthermore, body condition did not decline over winter even in the smallest fragments. Body condition was assessed by actual body mass less size-predicted body mass (using principal components analysis based on anatomical measurements).

Although Wunderle and Latta (2000) found that the three migrant species were largely indifferent to fragment size, a few bird responses suggested that some edge effects existed. These responses included reduced site persistence by American Redstarts (both within and between winters), reduced persistence from early to midwinter by Black-and-white Warblers, and a nonsignificant tendency for Black-throated Blue Warblers to persist relatively poorly over the winter in the smallest fragments. The authors acknowledge that statistical power to detect such effects was weak, so the appearance of these effects in two of the three species is suggestive of a real, albeit weak effect. Wunderle and Latta argue that none of the three species probably encountered food shortages in the smallest fragments, and that avian predators may have influenced target species responses to fragment size. Sharp-shinned Hawks (*Accipiter striatus*) were implicated as likely predators, and possibly American Kestrels (*Falco sparverius*) as well, based on remains of an American Redstart and Black-throated Blue Warbler in plantations, and observations of both of these raptors in (Sharp-shinned Hawk) and around the fragments. Wunderle and Latta suggest that plantations that are too small to contain a warbler's home range force individuals to move beyond the plantation, where predation risk consequently increases. More research is needed to confirm any such predation-based edge effect, but it raises interesting questions. For example, does predation risk to migrants occupying forest edges vary geographically across the northern Neotropics, the way habitat-use patterns do (Petit et al. 1995)? Does the effect of fragmentation on migrants disappear in countries such as Jamaica, which harbors no Sharp-shinned Hawks (Bond 1993) and few other predators of small birds, compared with the predator-rich mainland countries of Central and South America?

Wunderle and Latta (2000) quantified the habitat matrix surrounding wooded fragments using 100-m transects out from the edge. The ability of the focal species to move in and out of the smallest plantations, with little apparent ill effects (except for possible predation risk), suggests that the surrounding matrix was hospitable. Indeed, American Redstarts and Black-throated Blue Warblers generally occupy diverse habitats in winter, including residential areas, isolated trees in pastures, hedge rows, and a wide variety of agricultural habitats (Wunderle and Waide 1993) and they exhibit corresponding dietary opportunism and foraging flexibility (Holmes 1994, Sherry and Holmes 1997). Wintering Blackcaps (*Sylvia atricapilla*) illustrate similar ecological flexibility within olive groves in southern Europe (Rey and Valera 1999). Are opportunists such as Wunderle and Latta's focal migrants unrepresentative of all bird species that feed within cultivated habitats? How disturbed or intensively cultivated would the tropical countryside have to be for even these opportunistic migrants to respond negatively to fragments that are smaller than home ranges? Resident birds that breed in fragmented tropical forests are influenced both by hostile edges and the nature of the matrix surrounding habitat fragments (e.g. Lovejoy et al. 1986, Stouffer and Bierregaard 1995, Gascon et al. 1999), just the same as many latitudinal migrants that breed in North America. How does habitat fragmentation affect resident birds breeding within shade coffee habitat in the Dominican Republic, or elsewhere in Latin America? Answers to such questions are needed to develop perspective about the net conservation benefits and risks of habitat fragmentation to diverse faunas and floras.

The second of Wunderle's and Latta's (2000) contributions is their evaluation of the quality of shade coffee plantations for wintering migrants. For example, persistence probabilities of the three warblers over the winter (65 to

76%, on average) and between winters (31 to 40%) fell within a range of values reported from natural habitats in the Caribbean. The male-dominated sex ratios of American Redstarts and Black-throated Blue Warblers, echoed by Black-and-White Warblers (but not significantly so), also support the contention that these birds are willing to fight for territories within this habitat. The authors observed wanderers of all three species attempting to displace territory holders from plantations, and occasionally filling in vacated territories when the original owners disappeared. Males also tended to persist over the winter better than females, significantly so in the Black-throated Blue Warbler. These observations are consistent with the ''male dominance'' winter habitat-selection hypothesis, which so far has been tested best in American Redstarts (Marra et al. 1993, 1998).

Birds should compete most intensively for winter territories in habitats that contain enough food to maintain body condition up to the time of spring migration, and shade coffee plantations support this idea. For example, Wunderle's and Latta's (2000) data indicate that body condition did not decline during the dry season for any of the three bird species, which also appeared to maintain high foraging rates throughout winter. Moreover, the abundance of Black-throated Blue Warblers in the plantations *increased* in winter during the late dry season, when birds are declining in condition or disappearing from some other Caribbean island habitats (Sherry and Holmes 1996, Marra and Holberton 1998). Wunderle's and Latta's observations add to a growing list of studies indicating that shade coffee provides a refuge for tropical birds during the dry season (Perfecto et al. 1996; Greenberg et al. 1997a, b). The quality of shade coffee habitat for so many birds probably derives from abundant food resources, particularly the cornucopia of nectar, fruit, and insects supplied by *Inga* shade trees (Wunderle and Latta 1998; Greenberg et al. 1997a, b). For example, *Inga vera* supported significantly higher insect abundance, and correspondingly more migrant birds, than *Pseudalbizia berteroana* in a Jamaican shade coffee plantation (Johnson 2000). Other questions that will need to be addressed to assess habitat quality of shade coffee plantations include how this habitat affects the birds' physiological condition, especially just prior to migration, and whether this condition carries over into the subsequent breeding period.

Studies that document how and why many birds, and a diversity of other animals, benefit from shade coffee plantations (Perfecto et al. 1996, Wunderle and Latta 2000) are important to conservation biology for several reasons. First, shade coffee plantations, and other traditional and rustic plantations, are disappearing rapidly. High-yield sun coffee monocultures (typically lacking the shade tree structure and flora), which need large amounts of pesticides and fertilizer, have rapidly replaced rustic and shade grown coffee since the mid 1970s in the northern Neotropics (Perfecto et al. 1996, Rice and Ward 1996). For example, sun coffee now constitutes about 69% of the coffee produced in Colombia, and about 40% in Costa Rica (Smithsonian Migratory Bird Center 1997). As the habitat diversity of traditional shade coffee farms is lost, so goes the diversity of animal species, and much of the conservation value of these plantations (Perfecto et al. 1996, Wunderle and Latta 1996, Greenberg et al. 1997a, Wunderle 1999). The production of sun coffee also tends to depend more on loans, capital investments, and technical expertise than traditional cultivation, and thus tends to cause more problems in the long run, both environmentally and socially, particularly for small-scale farmers (Perfecto et al. 1996, Rice and Ward 1996, Smithsonian Migratory Bird Center 1997).

The second motivation for conservation interest in coffee plantations and other human-created habitats is that they occupy a large proportion of many tropical landscapes. Shade coffee plantations occupy about 50% of permanent croplands in the Caribbean Islands, Central America, and Colombia (Smithsonian Migratory Bird Center 1997). Only about 3.2% of terrestrial lands globally are in parks, and much of the rest is under management by humans (Pimentel et al. 1992). Human-managed habitats can never replace the reserves of native and old-growth forest habitats on which many species depend for their survival, but some kinds of agricultural habitats have the virtue of simultaneously providing for human subsistence and supporting a diversity of species. Examples of such win-win habitats include diverse gradations of shade coffee cultivation, ca-

cao and cardamom plantations, kitchen gardens, some forested and grazed ecosystems, and various extractive forest reserves (Pimentel et al. 1992, Perfecto et al. 1996, Rice and Ward 1996, Greenberg et al. 1997a, Vandermeer and Perfecto 1997, Steinberg 1998).

A third reason that conservation biologists value shade coffee plantations derives from their ecosystem services. For example, birds suppress populations of plant herbivores (arthropods >5 mm length) and reduce damage to coffee leaves, based on an exclosure experiment in Guatemala (Greenberg et al. 2000). Other predators such as spiders and ants consume herbivores and thus potentially help control pest populations and possibly even benefit the growth of coffee plants. Conversion of shade to sun coffee may increase pest loads on coffee plants by reducing plant diversity along with populations of pest-control organisms, thereby necessitating more pesticides in sun coffee (Perfecto et al. 1996, Power and Flecker 1996). In a test of this idea, Greenberg et al. (2000) found that bird consumption of arthropods was no greater in sun coffee than in shade grown plantations. American Redstarts eat a bean pest, the coffee berry borer (*Hypothenemus hampei*; T. W. Sherry, M. D. Johnson, and A. Medori unpubl. data), although this predator's effectiveness in controlling the pest is not known. The potential effect of predators and parasites on coffee pests is a fruitful field for future research. Another ecosystem service of shade coffee plantations is the soil fertility provided, again free of cost to the farmer, by nitrogen-fixing shade tree species such as *Erythrina, Gliricidia, Inga,* and *Pseudalbizzia.*

Wunderle and Latta's (2000) analysis of habitat edge effects, and their sustained (if not sustainable) research efforts on shade coffee plantations, are important because they help land managers protect the maximum possible diversity of organisms within landscapes. For example, even small shade coffee plantations enhance survival of wintering migrants in landscapes with few other trees. This is not enough, however, to protect biological diversity if environmentally beneficial habitats and their component species are overcome by the economic, political, and social interests of humans. Despite these forces, individual consumers who care about the environment can have a positive effect by consuming shade grown (in practice, certified organic) coffee, which is now widely available through internet sites and other markets (e.g. Rice and Ward 1996, Smithsonian Migratory Bird Center 1999, Mader 2000). These specialty coffees typically are more expensive than other brands, but they are well worth it if their consumption helps protect migratory birds. Unfortunately, far too few consumers in the United States know (or care?) to choose ecologically correct brands, although this can change with public education. Meanwhile, I'll go brew myself some of the good stuff, shade grown organic, of course!

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