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Chacha Werema & Kim M Howell

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Short Note

Seasonal variation in diversity and abundance of understorey birds in Bunduki Forest Reserve, Tanzania: evaluating the conservation value of a plantation forest

Chacha Werema* and Kim M Howell

Department of Zoology and Wildlife Conservation, University of Dar es Salaam, Tanzania
** Corresponding author, email: cwerema@yahoo.co.uk*

Plantation forests generally support lower bird diversity than natural forests. However, in some instances the plantations have been found to provide suitable habitat for a number of bird species. In the Eastern Arc Mountains, there is limited knowledge how understorey birds, some of which make seasonal altitudinal movements, use plantations. Using mist netting we assessed seasonal use of the plantation forest by the understorey bird community in Bunduki Forest Reserve in the Uluguru Mountains. Species diversity and capture rates were significantly higher during the cold season than during the hot season possibly due to seasonal altitudinal migration by some species. The use of plantations by those species that make seasonal altitudinal movements shows that plantation forests can enhance indigenous biodiversity by enabling connectivity between two or more natural forest patches. Our findings suggest that in a situation where there is no natural forest, an exotic plantation with suitable indigenous understorey cover can help in protection of birds, including endemic and near-endemic species.

Keywords: birds, conservation, Eastern Arc Mountains, plantation, seasonal altitudinal migration, seasons, species diversity

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There has been considerable interest in the distribution and abundance of indigenous biodiversity in plantation forests (Norton 1998). Studies in East Africa (Carlson 1986; Pomeroy and Dranzoa 1998; Newmark 2002; Farwig et al. 2008), Europe (Moss 1978; Nilsson 1979), North America (Noble and Hamilton 1976) and Australia (Disney and Stokes 1976; Suckling et al. 1976) have found that plantations support fewer bird species and lower total diversity than natural forests. However, in some instances plantation forests have been shown to provide habitat for a number of indigenous birds (Clout and Gaze 1984; John and Kabigumila 2011), especially when these forests have an understorey of native vegetation (Clout and Gaze 1984; Waltert et al. 2004). This is principally the case in older plantations whose understories are floristically similar to natural forests (Duran and Kattan 2005) and, in addition, possess an increased spatial and vertical structural heterogeneity (Clout and Gaze 1984).

In East Africa, natural forests have been cleared for cultivation, logged for timber, exploited for non-timber natural products and converted to plantations (Carlson 1986; Newmark 2002). This situation is particularly critical in the Eastern Arc Mountains where approximately 76% of the original 23 300 km^2 forest cover has been lost during the last two centuries and over the last century about 115 km^2 of the natural forest in these mountains have been converted to plantations (Newmark 2002). As a result, plantations have continued to be an important part of forestry in some of the Eastern Arc Mountains of Tanzania.

Compared with natural forests, however, there is limited knowledge on the role of plantations in conservation of forest birds in the Eastern Arc Mountains. The only studies on the use of plantations by birds are those of Newmark (2002) and John and Kabigumila (2007, 2011) in the Usambara Mountains. Newmark (2002) assessed the number of bird species of understorey forest-dependent bird species in *Eucalyptus* and natural forests in the East and West Usambara Mountains and found that plantations had fewer species compared with natural forests. John and Kabigumila (2007) assessed the role of *Eucalyptus* plantations on nesting bird species in the East Usambara Mountains and found that the plantations had low densities of nests compared with the natural forest. However, John and Kabigumila (2011) concluded that well-managed exotic plantations can provide hospitable habitats for local avifauna. Despite these two studies, in the Uluguru Mountains, no study has looked at the conservation importance of plantations for understorey birds, including those species that make seasonal altitudinal migration. This aspect is important because in the Uluguru Mountains, most of the lower-altitude forests have been cleared (Burgess et al. 2002) and it is possible that deforestation may have negatively affected forest birds that make seasonal altitudinal migratory movements between montane and lowland forests (Stuart 1983; Burgess and Mlingwa 2000; Werema 2007).

Though lacking a comparative natural forest of a more or less similar size and at the same elevation in the Uluguru Mountains, in this paper we aim to provide an initial

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assessment of the ability of plantations with an understorey layer composed of indigenous vegetation to accommodate understorey birds, including species of conservation importance and seasonal altitudinal migrants.

The study was carried out in the Bunduki Forest Reserve in the Uluguru Mountains, eastern Tanzania. The Uluguru Mountains form one of the component blocks of the Eastern Arc Mountains and are known for a high degree of endemic vertebrate and plant taxa (Burgess et al. 2002; Rovero et al. 2014). Among the Eastern Arc Mountains of Tanzania, the Uluguru Mountains rank second in the number of endemic species (Rovero et al. 2014). In the Uluguru Mountains there is heavy rainfall throughout the year with the peak rainy season between March and April. The peak rainy season is accompanied by a fall in temperatures, a situation continuing into the June–September dry season, which is the coolest time of year.

Bunduki Forest Reserve (111 ha; Figure 1) is mainly a plantation of several exotic species, such as *Pinus* sp., *Eucalyptus* sp., *Cupressus* spp. and *Grevillea robusta*. The latter is the dominant species in the plantation. The understorey layer, however, contains some montane native tree and shrub species, including *Albizia gummifera*, *Psychotria goetzii*, *Oxyanthus speciosus*, *Morus alba*, *Bridelia micrantha*, *Macaranga capensis* and *Cussonia spicata*. The forest ranges in altitude from 1 220 to 1 540 m above sea level and mainly falls in a submontane zone (Burgess et al. 2002).

We surveyed the understorey avifauna using mist nets (12 m, 16 mm mesh, four tier). The studies were conducted during the hot season (February 2011) and cold season (July 2011). During each season 15 mist nets were erected forming a T-shaped net line for 36 daylight hours and were operated from dawn (06:00) to dusk (18:00) for three consecutive days. The nets were located more than 100 m from the forest edge because forest edge microclimatic gradients extend on average less than 100 m from the forest edge (Newmark 2001). Net locations and sampling efforts were the same during each season. Mist netting effort was 6 480 metre-net hours during each season making a total of 12 960 metre-net hours.

The birds in the study area were divided into two groups: forest dependent and non-forest species (Stuart and Jensen 1985). Forest species were further divided into forest specialists (FS species), which are 'true' forest birds of the interior undisturbed forest, and F species, which may occur in undisturbed forest but are in most cases found in forest gaps and edges. Non-forest species (NFS species) are birds that are occasionally found in the forest but are not dependent on it for their survival (Stuart 1983; Newmark 1991). In addition, the birds were grouped into two categories: altitudinal migrants and non-altitudinal migrants (Burgess and Mlingwa 2000; Stuart 1983, Stuart and Jensen 1985; Werema 2007, 2015, in press).

Because mist nets were used to sample birds, only species that forage in the understorey were surveyed. Although some species, such as Bar-tailed Trogon *Apaloderma vittatum* and Green Barbet *Stactolaema olivacea*, can feed in the mid and upper strata of the canopy (Newmark 1991), they are still known to feed in the understorey layer (Romdal 2003). Therefore to avoid misinterpretation we consider all captures as part of the understorey bird community.

Assuming equal number of captures between seasons, a chi-square test (Yates corrected) was used to assess whether there were differences in captures of individuals between seasons. Species diversity during each season was calculated using the Shannon–Wiener index of diversity. Using the software package PAST (Hammer et al. 2001), a *t*-test was used to determine whether there were seasonal differences in species diversity between cold and hot seasons (Hutcheson 1970; Magurran 1988). Throughout this note, species nomenclature follows Sinclair and Ryan (2003).

By pooling data from the two seasons, 406 captures (excluding same-season recaptures) representing 26 species were mist netted over 12 960 metre-net hours. All but one species mist netted, the African Yellow White-eye *Zosterops senegalensis*, were forest dependent (both FS and F species; Tables 1 and 2). Two species, the Uluguru Mountain Greenbul *Andropadus neumanni* and Loveridge's Sunbird *Cinnyris loveridgei*, are endemic to the Uluguru Mountains. Six additional species have been categorised as near-endemic (Table 2; Burgess et al. 2007).

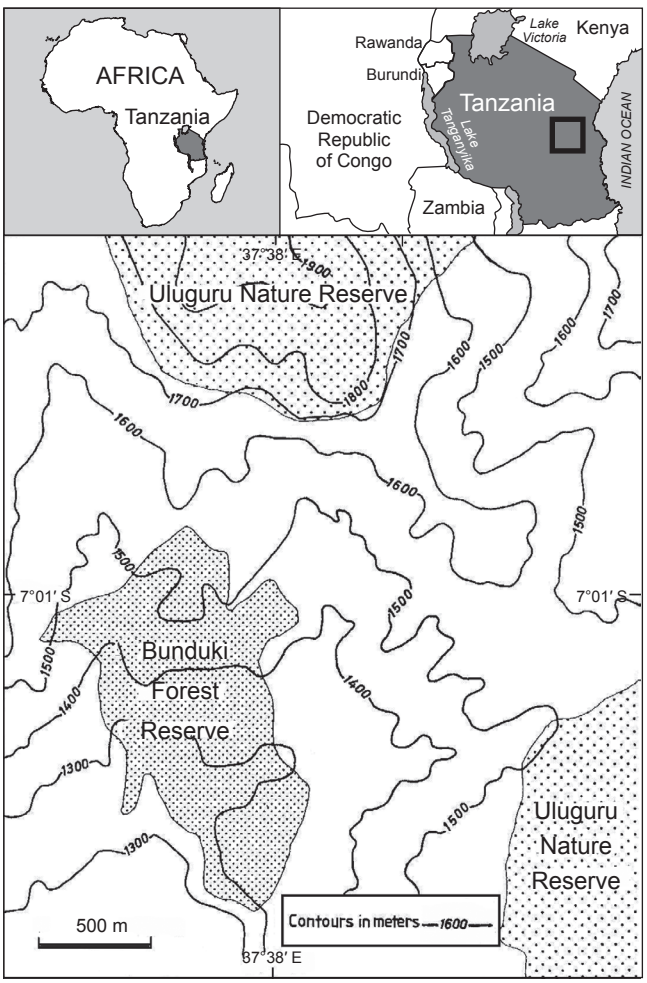


Figure 1: Location of Bunduki Forest Reserve. Also shown on the map is the Uluguru Nature Reserve (formerly Uluguru North and South Forest Reserves)

Of all captures, 23 individuals (six species: Shelley's Greenbul *Andropadus masukuensis* [6], Cabanis Greenbul *Phylastrephus cabanisi* [6], Little Greenbul *Andropadus virens* [5], Olive Sunbird *Cynomitra olivacea* [4], Forest Batis *Batis mixta* [1] and Stripe-faced Greenbul *Andropadus striifacies* [1]), which were ringed during the hot season in February 2011, were recaptured during the cold season in July 2011. In addition, over each of the three days of netting sessions during each season, capture rates declined.

Of a total of 406 captures of birds, 241 (59.4%) were mist netted during the cold season and 165 (40.6%) during the hot season and the difference was significant ($\chi^2 = 13.85$, df = 1, $p < 0.001$). Of the total captures, 313 (77%, 15 species) were of species known to make seasonal altitudinal migrations (Stuart and Jensen 1985; Burgess and Mlingwa 2000; Werema 2007) in the Uluguru Mountains and 93 (23%, 11 species) were of species that have not been known to make seasonal altitudinal movements. Species diversity values (*H'*) during the cold and hot seasons were 2.475 and 2.273, respectively ($t = 1.988$, df = 401.66, $p < 0.05$). When known seasonal altitudinal migrants (Stuart and Jensen 1985; Burgess and Mlingwa 2000; Werema 2007) were analysed separately, there was a higher abundance of known altitudinal migrants during the cold season than hot season ($\chi^2 = 12.28$, df = 1, $p < 0.001$). However, when altitudinal migrating species were removed from the analysis (i.e. by analysing data for only year-round resident species) there was no difference in number of captures between the cold and hot seasons ($\chi^2 = 1.54$, df = 1, $p > 0.25$).

The results of this study suggest that the plantation forest can support interesting avian diversity including two species endemic to the Uluguru Mountains, *A. neumanni* and *C. loveridgei* (Sinclair and Ryan 2003), and six

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Table 1: Numbers of species and individuals captured at each site during the cold and hot seasons. Numbers of species are grouped into their respective forest dependence categories. FS = forest specialists; F = forest birds that may occur in undisturbed forest but found in forest strips, gaps and edges; NFS = those species that are not dependent on the forest for their survival but may be found inside the forest (also see Table 2)

Number of species						Number of captures	
Cold season			Hot season			Cold season	Hot season
FS	F	NFS	FS	F	NFS		
20	5	1	11	4	0	241	165

Table 2: Catch rates (per 1 000 metre-net hours) of bird species in the plantations that were sampled. FS = forest specialists; F = forest birds that may occur in undisturbed forest but found in forest strips, gaps and edges; NFS = those species that are not dependent on the forest for their survival but may be found inside the forest; E = species endemic to the Uluguru Mountains; NE = near-endemic species (Burgess et al. 2007). * Species known to be altitudinal migrants

Forest dependence and endemicity	Species	Season	
		Cold season	Hot season
FS	*Aplopelia larvata* Lemon Dove*	0.309	0
FS	*Turtur tympanistria* Tambourine Dove	0.154	0
FS	*Apaloderma vittatum* Bar-tailed trogon*	0.154	0
FS, NE	*Stactolaema olivacea* Green Barbet	0.617	0.926
FS, NE	*Modulatrix stictigula* Spot-throat*	0.154	0
FS	*Phylastrephus cabanisi* Cabanis Greenbul	2.778	3.241
F	*Andropadus virens* Little Greenbul*	8.796	5.864
FS, NE	*Andropadus masukuensis* Shelley's Greenbul*	4.630	3.858
FS, NE	*Andropadus striifacies* Stripe-faced Greenbul*	1.852	1.698
FS, E	*Andropadus neumanni* Uluguru Mountain Greenbul*	0.154	0
FS	*Zoothera gurneyi* Orange Ground-Thrush*	0.154	0
FS	*Turdus abyssinicus* Mountain Thrush	1.235	0.309
FS	*Pseudalethe fuelleborni* White-chested Alethe*	0.309	0
FS	*Pogonocichla stellata* White-starred Forest Robin*	0.926	1.235
FS	*Bradyptrus lopezi* Evergreen Forest Wabler*	0.154	0.154
FS, NE	*Artisornis metopia*s African Tailorbird	0.463	0.309
F	*Terpsiphone viridis* African Paradise Flycatcher	0.154	0.617
FS	*Trochocercus cyanomelas* Blue-mantled Crested Flycatcher	0.154	0
F	*Elminia albonotata* Crested Flycatcher*	1.235	1.235
FS, NE	*Batis mixta* Forest Batis*	0.926	0.463
FS	*Cynomitra olivacea* Olive Sunbird*	6.790	4.012
F	*Hedydipna collaris* Collared Sunbird	1.080	0.309
FS, E	*Cinnyris loveridgei* Loveridge's Sunbird*	0.463	0
NFS	*Zosterops senegalensis* African Yellow White-eye	0.309	0
FS	*Cryptospiza reichenovii* Red-faced Crimsonwing*	3.086	1.235
F	*Linurgus olivaceus* Oriole Finch	0.154	0

near-endemic species. This observation is in line with the findings of John and Kabigumila (2011), who reported that plantations can have potential value to some bird species of conservation value, including those that are endemic, threatened and endangered. On the conservation value of the understorey native plant species layer, the results are also consistent with the findings of John and Kabigumila (2007, 2011) who found that, in *Eucalyptus* plantations in the Usambara Mountains with a good understorey layer of indigenous trees, there were more bird species nesting and forest-dependent species in them than plantations that had no understorey layer.

The higher species diversity and captures of individuals during the cold season than during the hot season was largely due to the capture of known seasonal altitudinal migrants during the cold season. The variation in the number of captures of birds was influenced by the arrival and departure of seasonal altitudinal migrants, a pattern that has been observed elsewhere in bird communities in montane forests in the Eastern Arc Mountains in Tanzania (Stuart 1983; Burgess and Mlingwa 2000; Cordeiro et al. 2006), in Malawi (Dowsett-Lemaire 1989) and in the Neotropics (Loiselle and Blake 1991; Blake and Roughes 1997).

The higher catch rates of Green Barbet *Stactolaema olivacea* and African Paradise Flycatcher *Terpsiphone viridis* during the hot season could be due to local movements, unrelated to altitude, that were undertaken by these species. The former is known to make local movements finding fruiting trees (Fry et al. 1988; Short and Horne 2001). *Terpsiphone viridis* is a well-known intra-African migrant and makes local movements and therefore it could have moved from the nearby areas (Urban et al. 1997).

We conclude that although the study is limited by lack of a comparable natural forest of similar size, altitude and distance from the higher-altitude forests, the results suggest that plantations with an understorey substratum and remnant native trees and shrubs can offer a useful environment for understorey forest-dependent species. The use of plantations by species that make seasonal altitudinal movements shows that plantation forests can enhance indigenous biodiversity by enabling connectivity between two or more natural forest patches. Reconnecting the Bunduki Forest Reserve with the Uluguru Nature Reserve should facilitate the seasonal movement of bird species with limited gap-crossing abilities (see Figure 1). Plantations with suitable plant species and conditions can facilitate migration between forest reserves/patches by linking metapopulations essential for sustaining overall metapopulation viability. Although we do not have direct evidence for altitudinal migration of birds at the study site, and that seasonal differences could be explained by changes in detectability and chance, the data presented here suggest that migration and possibly dispersal lead to seasonal differences in diversity and abundance of birds. This further suggests that altitudinal migration of birds is an important component of the dynamics of communities in the Uluguru Mountains. Our findings suggest that in a situation where there is no natural forest, an exotic plantation with suitable understorey vegetation cover can help in protection of birds including endemic and near-endemic species.

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