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Avian Use of Habitat Patches Dominated by Exotic *Leucaena leucocephala* or Native Tree Species in Urban Dar es Salaam, Tanzania

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Abstract

There has been an incursion of an exotic *Leucaena leucocephala* in disturbed areas and into habitat patches of native tree species in some areas in Tanzania. However, the impacts of this exotic tree on native biodiversity are not well understood. We assessed bird use of habitat patches dominated by *L. leucocephala* in comparison to patches of native tree species at the University of Dar es Salaam main campus, Tanzania, by comparing bird species richness, abundance and diversity using mist netting. Based on the same mist netting efforts in each habitat patch type, patches of native trees had significantly higher overall diversity ($t = 1.999$, $df = 293.64$, $p < 0.05$) and abundance ($\chi^2 = 40.525$, $df = 1$, $p < 0.001$) of birds than those dominated by the exotic *L. leucocephala* and significantly greater abundance of forest-dependent species ($\chi^2 = 10.938$, $df = 1$, $p < 0.001$) and forest visitors ($\chi^2 = 15.258$, $df = 1$, $p < 0.001$). The similarity in bird species between the two habitats was 0.658 indicating that many bird species occurred in both habitat types. The lower diversity and overall abundance of birds in the patches dominated by the exotic plant suggest that it does not provide appropriate habitat for many bird species, and further spread of this exotic will be detrimental to the local avifauna.

Keywords: Birds, diversity, native tree species, exotic tree species, *Leucaena leucocephala*.

Introduction

The incursions of exotic plants into native vegetation or disturbed areas, and their subsequent establishment and spread, can cause substantial structural changes in habitat diversity leading to considerable ecological effects on vertebrate taxa, e.g. birds (Schmidt and Whelan 1999). In some cases, it is unclear whether such incursions are associated with regular changes (declines or increases) or possibly no changes in the diversity and abundance of fauna (e.g. birds). A review on effects of exotic plants by Murray et al. (2007) showed that species richness of birds tended not to differ between exotic and native sites. However, some studies have reported decreased avian species richness and diversity in habitats with exotic plant species (including plantations). For example, in central Tanzania where *L. leucocephala* was used in rehabilitation of mined areas, sites dominated by this exotic plant had lower density of bird species and individuals and lower relative abundances and species diversity in comparison with sites rehabilitated with native species, and surrounding intact woodlands (Werema 2021). Elsewhere, lower species richness and diversity of birds have been reported in exotic plantations in comparison with the native vegetation [e.g. species number: Carlson (1986) in Kijabe, Kenya, Pomeroy and Dranzoa (1998) in Kenya and Uganda, Farwig et al. (2008) and Bett et al. (2016) in western Kenya, and Sekercioglu (2002) in Kibale National Park, Uganda; diversity:

Griffin et al. (1989) in Australia, John and Kabigumila (2007) in Tanzania, Munyekenye et al. (2008) in western Kenya; species richness and diversity: Dean et al. (2002) in South Africa].

At the University of Dar es Salaam main campus (hereafter the campus), patches of coastal thickets provide habitat for a number of bird species (Harvey and Howell 1987, Mlingwa 1992). These thickets are now habitat islands in an urban landscape. The thickets are mainly composed of native tree and shrub species but there are some incursions of exotic trees such as Neem tree *Azadirachta indica* and white tamarind *Leucaena leucocephala*. The latter species is common at disturbed areas and thicket edges (particularly along some roads on the campus). Recently some coastal thickets at the campus have been cleared to build offices and lecture rooms. In levelling the ground, tonnes of soils have been dumped at, and in the vicinity of, some construction sites, and here the exotic *L. leucocephala* has become established. The seeds of this plant germinate easily, and the tree is highly tolerant of drought mainly because of its extensive root system. Within a few years, seedlings of this exotic plant have dominated the native trees at some places, particularly at disturbed sites (e.g., due to construction activities), and some of them are already large trees. Thus, at present, there are fragments/habitat patches and disturbed sites which were dominated by native trees, but have been taken over by this exotic plant.

Although several studies on the avifauna of the coastal forests (e.g., Pande, Pugu and Kazimzumbwi: Burgess et al. 1991, Mlingwa et al. 1993), including the coastal thickets found in the University of Dar es Salaam campus (Mlingwa 1992) exist, to the best of our knowledge, there has been no study on the impacts of the incursion of the exotic *L. leucocephala* on birds in the coastal areas of Tanzania. Combined with the data in Werema (2021), such a study would significantly improve our understanding of the impacts of this exotic plant on bird species conservation. Here we compare the avifauna mist netted in patches dominated by the exotic *L. leucocephala* to control thickets of native plant species. This study is intended to provide a basis for more detailed studies of impacts of exotic plant species on birds, particularly in places where *L. leucocephala* is present, since this invasive plant species is likely to dominate some landscapes. The objectives of this study were to compare: 1) species richness and diversity of birds inhabiting patches of native trees and those dominated by *L. leucocephala*; and 2) bird species composition between these habitats. We hypothesized that patches of native tree species would have (i) different bird species composition, (ii) higher bird species diversity, and (iii) higher overall abundance and abundance of forest-dependent species of birds as well as forest visitors, in comparison with patches dominated the exotic *L. leucocephala*.

Materials and Methods

Study area

The main campus of the University of Dar es Salaam covers about 6 km^2 (6°46′ S–6°47′ S, 39°12′ E–39°14′ E) at 40–100 m above sea level. It falls within the Zanzibar Inhambane Region Mosaic vegetation. The natural vegetation at the campus was once dominated by forest, but most of it disappeared due to clearance for agriculture and buildings in the past (Wingfield 1977). By the 1960s the campus was largely a bushland with scattered huts and pockets of permanent and seasonally cultivated crops including cassava (*Manihot esculenta*), cashew nuts (*Anarcadium occidentale*), coconuts (*Cocos nucifera*) and mango (*Mangifera indica*) (Senzota 2012). Much of the natural vegetation in form of indigenous trees and dense thickets remained until 1975 (Mlingwa 1992). During the last quarter a century, the campus has continued to retain its indigenous vegetation due to protection from wood collection and cultivation (see Senzota 2012). The thickets found at the campus stand out as habitat islands in a sea of human settlements, campus buildings and roads (see Senzota 2012). While the the natural vegetation of the campus was once a forest (Mlingwa 1992), recently much of the remaining natural vegetation and dense secondary growth has been reduced due to construction of new buildings.

The campus receives over 1,100 mm of rainfall annually (White 1983). Annual temperatures average about 24 °C and humidity can reach 100% in January, February and March (Senzota 2012).

Study sites

The four study sites were broadly categorized into two habitat patch types: patches of native tree and shrub species (ca. 11 ha and 12.5 ha; hereby patches of native trees) and patches dominated by the exotic *Leucaena leucocephala* (*ca*. 1.5 ha and 2 ha). The two patches dominated by *L. leucocephala* are separated from each other by a road about 15 m wide and each of these patches is less than 100 m away from one of the patches dominated by the native tree species (Figure 1). Prior to 2012, the patches dominated by the exotic *L. leucocephala* did not exist, the area was occupied by native tree species and was continuous with one of the patches of native tree species sampled (i.e., the patch on the eastern side; Figure 1). Thus, these are fragments of an originally large patch (thicket) (Figure 1). Each of these patches is separated from the nearby patch of native trees by a cleared electricity line corridor. The two patches of native trees were about 300 m from each other (Figure 1).

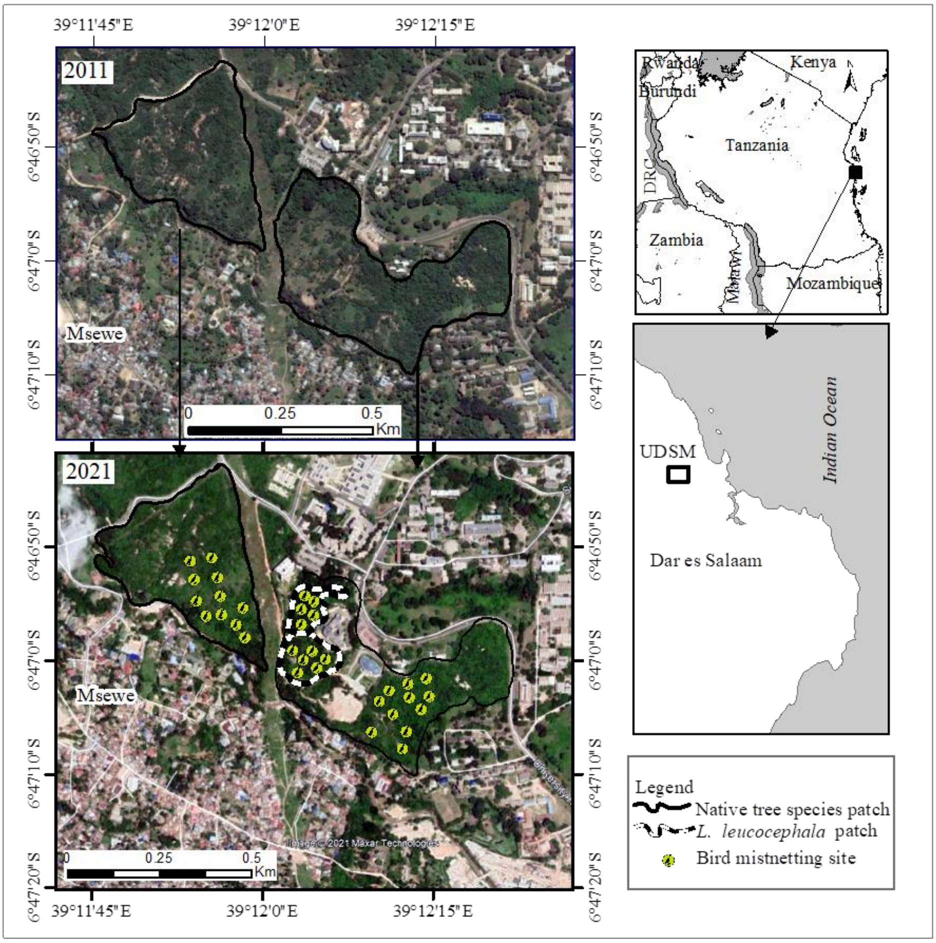

Figure 1: Study area showing the thickets sampled. Note the two intact paches in the northern part of the map and that the patches dominated by *L. leucocephala* did not exit prior to 2011 before construction of some buildings.

Vegetation structure and composition

Since structure of the vegetation, its complexity and vertical arrangement are among the primary defining factors in bird communities (Willson 1974, Skowno and Bond 2003), at each habitat patch, we sampled vegetation variables that might explain bird species composition: height profile, plant species composition and tree density. Height profiles of herbaceous and woody plants were estimated using a tall graduated pole with metre rule demarcations. Height profiles were constructed by estimating projected canopy cover in the height classes (bands) 0–1 m, 1–3 m, 3–5 m and > 5 m above-ground level (see Dean et al. 2002). These were measured in 10 m x 10 m plots set out at the sites where mist nets were erected. Fifteen plots were sampled at each of the patches of the native tree species and those dominated by the exotic *L. leucocephala*. Tree species present in each plot were identified and counted. The proportion of the exotic *L. leucocephala* in the patches dominated by this species was evaluated at each plot.

Bird survey method

Bird communities were sampled using mist-nets. While the mist nets do not sample mid- and upper canopy, they were used because they allow a standardized approach to surveying understorey birds which are often difficult to detect and identify visually (Bennun and Howell 2002). The mist nets are excellent for assessing relative abundance of birds since their use avoids the obvious biases of censusing techniques that rely on the visual and auditory ability of human observers (Karr 1981, 1990). Eleven mist nets (8 nets each 12 m and 3 nets each 9 m long), each with four shelves, 2.6 m high and 30 mm mesh size were set (with varied orientations) in the two patches of native trees and in the two patches dominated by *L. leucocephala* during 14th–23rd January 2021, 5th–12th February 2021 and 24th–27th February 2021. Nine mist nets each 12 m long (four shelves, 2.6 m height and 30 mm mesh size were set in each habitat patch mentioned above from 6th–9th October 2021. Net sites covered representative microhabitats in each habitat patch type. Nets were opened at around 6:00 a.m. and monitored until 1800 hrs after which they were closed. The nets were checked every 30–45 minutes. Total netting effort amounted to 14, 922 metre-net-hours at each habitat patch type.

Data analysis

Projected canopy cover per each plot at each height profile was transformed using logit transformation (Warton and Hui 2011). Following this transformation, a two sample t-test was used to test for any differences in the projected canopy cover for < 1 m, 3–5 m and > 5 m height profiles between the plots of native tree species and those dominated by the exotic *L. leucocephala*. However, for the height class 1–3 m, the data were not normally distributed, so we used the Mann-Whitney U test to test for any differences in projected canopy cover between the plots of native tree species and those dominated by the exotic *L. leucocephala*. Number of trees per 100 m^2 and tree heights in the plots of native tree species and those dominated by the exotic *L. leucocephala* were tested for normality using using the Shapiro–Wilk test (Shapiro and Wilk 1965). However, since the data were not normally distributed, the Mann-Whitney U test was used to test for any differences in these values between the plots of native tree species and those dominated by the exotic *L. leucocephala*. Plant species diversity of each plot in patches of native trees and those dominated by the exotic *L. leucocephala* was computed using the Shannon-Wiener diversity index (*H′*) (Hutcheson 1970, Magurran 1988). *H′* was computed using the formula defined by Hammer et al. (2001) as:

$$H' = -\sum_{i=1}^{s} p_i \ln p_i - \frac{S-1}{2N}$$

Where p_i is the proportion of the total number of individuals consisting of the *ith* species, *s* the number of species and N the number of individuals.

H′ was computed using Paleontological Statistics Version 4.06 (PAST; Hammer et al.

2001). The diversity data per plot in each patch of native trees and those dominated by the exotic *L. leucocephala* were tested for normality using the Shapiro–Wilk test (Hammer et al. 2001). Since the data were not normally distributed, the Mann-Whitney U test was used determine whether there were significant differences in species diversity between the patches of native trees and those dominated by the exotic *L. leucocephala*. This was also performed using PAST (Hammer et al. 2001).

Similarity in bird species between the two habitat patch types was computed using the Sorensen Similarity Index (SSI) (Magurran 1988). This index was computed as:

$$SSI = \frac{2a}{b + c}$$

where, a = the number of species found in each habitat, b = the number of species found in native thicket and c = number of species found in the exotic patch.

Assuming equal numbers of captures between the two habitat patch types (because of equivalent sampling efforts at each habitat patch type), a Chi-square test (with Yates correction) was used to assess whether there were differences in the overall captures of birds. The Chi-square test was also used to assess whether the numbers of individuals of each species mist netted differed between the two habitat patch types. Since sample size must be sufficiently large so that each expected frequency is at least 5 (Glover and Mitchell 2015), analyses were conducted on species that had at least 10 individuals either in the patches of native trees or in those dominated by *L. leucocephala* (see Hutto and Patterson 2016). The Chi-square test was applied only to 8 species that had at least 10 individuals (in either habitat patch type). Because this involved multiple comparisons (8 comparisons), we controlled for type I error with Bonferroni corrections by dividing 0.05 by 8 so that the difference was considered significant if $p < 0.006$ (see Rice 1989).

The birds in the study area were divided into two groups: forest-dependent species and forest visitors (Bennun et al. 1996). Forest-dependent species were Forest Specialists (*FF* species) which are birds of the forest interior that are likely to disappear when the forest is modified and Forest Generalists (*F* species) which occur in undisturbed forests but are able to exist in modified and fragmented forests as well as forest edge (also see Mlingwa et al. 2000). *F* species still depend upon the forest for some of their resources like nesting sites. Furthermore, forest visitors (*f* species), the species which are often recorded in forest, but are not dependent upon it were assessed. These are commonly found in non-forest habitats, where they are most likely to breed (Bennun et al., 1996). Assuming equal abundances of birds in their forest-dependency guild categories between the two habitat patch types, a Chi-square test (with Yates correction) was used to assess whether there were differences in abundances of birds in forest-dependent species (both *FF* and *F* species) and forest visitors (*f* species).

Bird species diversity of each habitat patch type was calculated using the Shannon–Wiener index of diversity (Magurran 1988). This diversity (H') per habitat patch type was calculated using the formula defined by Hammer et al. (2001) as explained above (for analysis of vegetation data). A t-test was used to determine whether there was a significant difference in bird species diversities between the two habitat patch types (Hutcheson 1970, Magurran 1988). This test was computed using PAST (Hammer et al. 2001). Common names and scientific names follow the International Ornithological Community World Bird Names v. 11.1 checklist (Gill et al. 2020).

Results

Vegetation structure and composition

The common tree species in the patches dominated by the exotic species were *L. leucocephala*, *Senna siamea*, *Peltophorum pterocarpum* and *Azadirachta indica*. All of these plant species are exotics. *L. leucocephala* made up 81% of the trees in these patches. The common shrubs in these patches were *P. pterocarpum, Pongamia pinnata*, *Albizia labbeck, Pluchea dioscoridis*, *Harrisonia abyssinica, Rhus* *natalensis* and *Lamprothamnus zanguebarica*. In the patches of native trees, the common tree species were *Albizia petersiana*, *Spirostachys africana*, *Tamarindus indica*, *Ozoroa insignis* and *Salvadora persica*. In this habitat patch type, there were more shrubs than trees and the shrub layer was dominated by *Harrisonia abyssinica*, *Dichrostachys cenerea*, *A. petersiana*, *Dalbergia obovata*, *Euclea natalensis*, *L. zanguebarica*, *Acalypha fruticosa*, *Grewia microcarpa*, *Uvaria kirkii*, *Dalbergia obovata* and *Bridelia carthatica*.

The projected canopy cover was higher in the patches of native trees than in those dominated by the exotic *L. leucocephala* for < 1 m, 1–3 m and 3–5 height bands (Figure 2). However, the difference was significant only for the height band 1–3 m (Mann Whitney U = 24.5, p = 0.0003). The projected canopy cover was higher in the patches dominated by the exotic *L. leucocephala* than those of native trees for the height band > 5 m (Mann Whitney U = 60, p = 0.003; Figure 2). The patches dominated by the exotic *L. leucocephala* had a higher mean tree height (mean ± SD 8.91 ± 0.21) than that of native tree species (mean ± SD 7.98 ± 0.24) (Mann Whitney U = 7455, p = 0.003) as well as the number of trees per plot (U = 50.5, p = 0.011). There was no significant difference in diversity of trees per plot between the two habitat patch types (U = 100, p = 0.604).

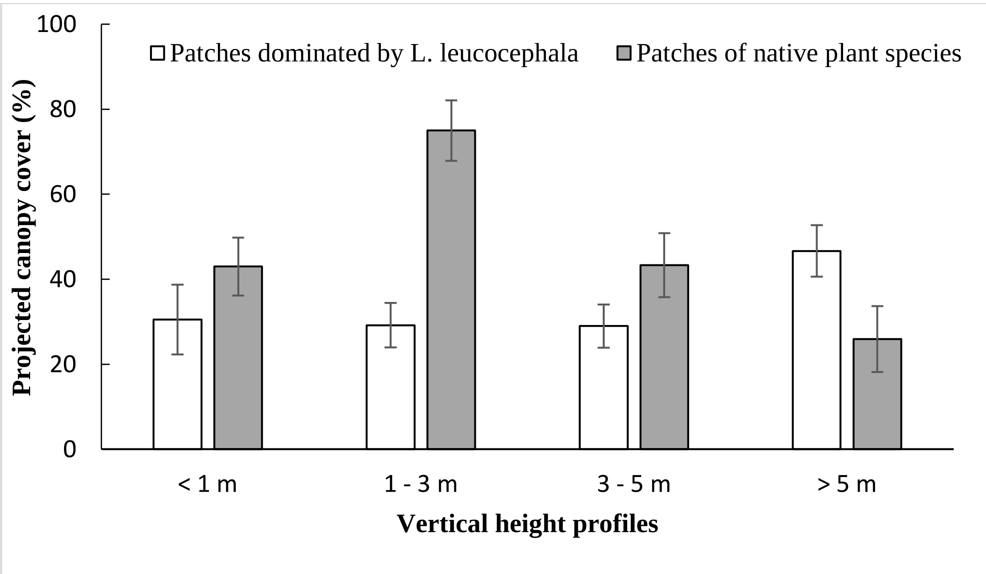

Figure 2: Projected canopy cover (± s.e.) of each vegetation height profile in habitat patches of native tree species and those dominated by exotic *L. leucocephala*.

Bird community structure and composition

By pooling data from the two habitat patch types, 398 captures were obtained (excluding recaptures) representing 49 species (Appendix 1). The most abundant species mist netted were Green-backed Camaroptera *Camaroptera brachyura*, Sombre Greenbul *Andropadus importunus*, Collared Sunbird *Hedydipna collaris* and Northern Brownbul *Phyllastrephus strepitans* (Appendix 1). Of the species mist netted 43 (263 individuals) and 30 (135 individuals) were captured in the patches of native tree species and those dominated by exotic *L. leucocephala*, respectively (Appendix 1). Twenty species were common to both habitat patch types and species similarity index was 0.658.

Significantly more birds were netted in the patches of native trees than in patches dominated by the exotic *L. leucocephala* (χ^2

= 40.525, df = 1, $p < 0.001$). Similarly, patches of native trees had a significantly higher bird diversity ($H' = 3.170$) than those dominated by the exotic *L. leucocephala* ($H' = 2.970$) ($t = 1.999$, df = 294, $p < 0.05$). None of the species mist netted was significantly more abundant in the patches dominated by *L. leucocephala* in comparison with the patches of native tree species. Three species, the Sombre Greenbul, Northern Brownbul and Terrestrial Brownbul *Phyllastrephus terrestris* were significantly more abundant in the patches of native tree species than in those patches dominated by the exotic *L. leucocephala* (Appendix 1).

Eleven forest dependent species (2 FF and 9 F species) were mist netted, all of which were captured in the thickets of native tree species, whereas seven species (1 FF and 6 F species) were caught in the patches dominated by the exotic *L. leucocephala* (Appendix 1). The patch of native trees had more forest-dependent species ($\chi^2 = 10.938$, df = 1, $p < 0.001$) as well as forest visitors ($\chi^2 = 15.258$, df = 1, $p < 0.001$) than the patches dominated by the exotic *L. leucocephala*.

Discussion

The avifauna in the patches dominated by the exotic *L. leucocephala* were less abundant and less diverse than in indigenous vegetation as reflected in the birds captured. No bird species had become over-abundant in the patches dominated by the exotic *L. leucocephala*. Werema (2021) also found lower bird species diversity in a mine site rehabilitated with *L. leucocephala* in comparison with sites rehabilitated with native tree species as well as unmined control sites in central Tanzania. Elsewhere, similar results have been reported by Carlson (1986) in Kijabe, Kenya and Pomeroy and Dranzoa (1998) in Kenya and Uganda who found decreased bird species in exotic pine plantations in comparison to indigenous (natural) forests, and in Australia by Griffin et al. (1989) who showed that replacement of indigenous *Eucalyptus* with alien tamarisk trees reduced bird abundance and diversity. Dean et al. (2002) reported lower species richness and diversity of bird communities in a woodland dominated by an alien *Prosopis* species in comparison with woodland of native *Acacia* species in South Africa. These suggest that incursions of exotic plant species do not act as substitutes for the native patches probably due to differences in habitat structure and plant species composition. The significantly lower projected canopy cover in the patches dominated by the exotic *L. leucocephala* in the 1–3 m layer (which was sampled most effectively by mist netting) seems to have an influence on the diversity and abundance of birds. Some bird species such as Northern and Terrestrial Brownbuls were not mist netted in the exotic patches, yet were abundant in the patches of native tree species probably due to the difference in crown cover between the two patches in the 1–3 m layer. The Terrestrial Brownbul is a forest-dependent species which prefers intact forests (Bennun et al. 1996) including primary and secondary evergreen forests and deciduous forests (Keith et al. 1992). The same may apply to the Northern Bronwbul which is known to inhabit thickets and forests (Keith et al. 1992) and the Sombre Greenbul. The latter species, while a non-forest dependent species (Bennun et al. 1996), was also significantly more abundant in the patches dominated by native tree species than in the those dominated by the exotic *L. leucocephala*. It is known to inhabit dense coastal scrub and thickets, preferring natural vegetation to man-made habitats (Keith et al. 1992).

The higher similarity index of bird communities between the two habitat patch types could be due to the precence of an understory layer of native shrubs in some parts of the patches dominated by the exotic *L. leucocephala*. This is a situation similar to instances where plantation forests with understories of native vegetation have been shown to provide habitat for a number of indigenous birds (Clout and Gaze 1984, Pomeroy and Dranzoa 1998, Waltert et al. 2004, Munyekenye et al. 2008, John and Kabigumila 2011, Werema and Howell 2016), particularly when understories of the plantations are floristically similar to natural forests (Duran and Kattan 2005, Munyekenye et al. 2008). Also, the higher similarity index of bird communities between the two habitat patch types could be because they are close to each other (< 100 m), so that individual birds can move between the patch types. This is possible for some species, including sunbirds which search for flowering plants (see Department of Ornithology 1997, Korfanta et al. 2012).

The presence of some forest-dependent and forest visitors in the patches dominated by the exotic plant is in line with the findings of Pomeroy and Dranzoa (1998) in Kenya and Uganda, Farwin et al. (2008) and Munyekenye et al. (2008) in western Kenya, John and Kabigumila (2011) in East Usambara Mountains, Tanzania, who reported that plantations have potential values to some bird species, including forest dependent species. The conservation value of the understorey of native plant species layer was also emphasized by Pomeroy and Dranzoa (1998) and John and Kabigumila (2007, 2011) who reported that plantations with a good understorey layer of indigenous trees had more forest-dependent species than plantations that had no understorey layer. Thus, despite the secondary nature of the patches dominated by *L. leucocephala*, they nevertheless support a number of species known to occur in forests (see Mlingwa 1992). However, forest-dependent bird species were less represented in the patches dominated by *L. leucocephala* than in those patches dominated by native tree species. Similar findings have been demonstrated in tree plantations in Uganda (Pomeroy and Dranzoa 1998, Sekercioglu 2002), Argentina (Zurita et al. 2006) and Kenya (Pomeroy and Dranzoa 1998, Farwig et al. 2008). Since the levels of forest dependence may be considered a useful tool for predicting species sensitivity to exotic plantations (Sekercioglu 2002), the low abundance and diversity of birds in patches dominated by exotic trees shows that this habitat was not suitable for many birds including the typical forest dwellers such as the Terrestrial Brownbul and forest visitors like the Northern Brownbul.

A minor potential caveat of this study is lack of data in patches whose sizes are more or less equal to those sites dominated by *L. leucocephala*. The lower number of captures and diversity of birds in the patches dominated by an exotic *L. leucocephala* in comparison with patches of native tree species could be due to small size of the former patches. In other urban areas (Park and Lee 2000, Kim et al. 2007) and non-urban areas (Newmark 1991, Dami et al. 2013) the abundances and diversity of birds tend to be lower in smaller patches (fragments) than larger ones. Nevertheless, although passive sampling (whereby large patches tend to have a higher probability of being occupied at random by a given species or individual; see Connor and McCoy 1979) may be a partial explanation for the results presented here, the use of equal sampling efforts in each habitat patch type could justify the impacts of the exotic plants in bird species abundance and diversity. Similarly, further justification is provided by the setting of the mist nets whereby they were not distributed throughout the patches dominated by native tree species.

Conclusion

The incursion of exotic plant *L. leucocephala* into native vegetation, and its subsequent establishment and spread at some patches on the campus severely reduced avian species diversity and abundance. This suggests that further spread of the exotic *L. leucocephala* at the campus and elsewhere would be detrimental to birds on a large scale. Further spread of the exotic *L. leucocephala* is to be discouraged. Protection of the remaining thickets at the campus is certainly needed to maintain the existing diversity of birds (Harvey and Howell 1987, Mlingwa 1992) especially for the conservation of forest-dependent species. However, because some bird species typical of the forest can use the thickets dominated by the exotic plant species to some extent, where native trees are absent, the exotic *L. leucephala* trees with an understorey of native shrubs can act as a stepping stone, facilitating dispersal of bird species among stands of natural vegetation.

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Appendix 1: Bird species captured in mist nets in patches of native trees species and patches dominated by an exotic *Leucaena leucocephala*. Native = patches of native species; Exotic = patches dominated by the exotic *L. leucocephala*. FD = forest dependency guilds after Bennun et al. (1996). *FF* species = forest specialists, *F* species = forest generalists and *f* species = forest visitors.

			Habitat patch type		Chi-square	p-value
FD	**Common name**	**Species name**	**Native**	**Exotic**	**test**	
	White-browed Coucal	*Centropus superciliosus*	1	0		
f	Emerald-spotted Wood Dove	*Turtur chalcospilos*	1	1		
	Brown-hooded Kingfisher	*Halcyon albiventris*	3	11	3.50	> 0.05
	African Pygmy Kingfisher	*Ispidina picta*	0	1		
	Little Bee-eater	*Merops pusillus*	0	2		
f	White-throated Bee-eater	*Merops albicollis*	1	0		
F	Yellow-rumped Tinkerbird	*Pogoniulus bilineatus*	2	0		
	Red-fronted Tinkerbird	*Pogoniulus pusillus*	9	6		
	Spot-flanked Barbet	*Tricholaema lacrymosa*	1	0		
f	Brown-breasted Barbet	*Lybius melanopterus*	2	0		
	Eastern Black-headed Batis	*Batis minor*	1	1		
F	Black-throated Wattle-eye	*Platysteira peltata*	9	2		
f	Orange-breasted Bushshrike	*Chlorophoneus sulfureopectus*	4	0		
	Brown-crowned Tchagra	*Tchagra australis*	1	2		
F	Black-backed Puffback	*Dryoscopus cubla*	1	0		
f	East Coast Boubou	*Laniarius sublacteus*	3	1		
FF	Blue-mantled Crested Flycatcher	*Trochocercus cyanomelas*	1	0		
F	Eastern Nicator	*Nicator gularis*	2	1		
	Sombre Greenbul	*Andropadus importunus*	36	5	21.95	< 0.001
F	Yellow-bellied Greenbul	*Chlorocichla flaviventris*	8	9		
F	Terrestrial Brownbul	*Phyllastrephus terrestris*	11	0	9.09	< 0.005
f	Northern Brownbul	*Phyllastrephus strepitans*	28	0	26.04	< 0.001
f	Dark-capped Bulbul	*Pycnonotus tricolor*	8	3		
	Red-faced Crombec	*Sylvietta whytii*	0	3		
	Rattling Cisticola	*Cisticola chiniana*	3	0		
f	Tawny-flanked Prinia	*Prinia subflava*	1	3		
f	Yellow-breasted Apalis	*Apalis flavida*	1	1		
f	Green-backed Camaroptera	*Camaroptera brachyura*	29	25	0.17	> 0.1

FD	Common name	Species name	Habitat patch type Native	Exotic	Chi-square test	p-value
	White-browed Scrub Robin	*Cercotrichas leucophrys*	8	5		
f	White-browed Robin-Chat	*Cossypha heuglini*	9	5		
F	Red-capped Robin-Chat	*Cossypha natalensis*	3	0		
	Spotted Palm Thrush	*Cichladusa guttata*	6	3		
F	Collared Sunbird	*Hedydipna collaris*	18	12	0.83	> 0.1
FF	Olive Sunbird	*Cyanomitra olivacea*	14	8	1.14	> 0.1
f	Grey Sunbird	*Cyanomitra veroxii*	11	9	0.05	> 0.1
	House Sparrow	*Passer domesticus*	0	1		
f	Thick-billed Weaver	*Amblyospiza albifrons*	1	0		
f	Spectacled Weaver	*Ploceus ocularis*	1	1		
	Golden-backed Weaver	*Ploceus jacksoni*	4	0		
	Yellow Bishop	*Euplectes capensis*	1	0		
	Bronze Mannikin	*Spermestes cucullata*	2	1		
f	Black-and-White Mannikin	*Spermestes bicolor*	0	2		
	Common Waxbill	*Estrilda astrild*	2	0		
	Blue Waxbill	*Uraeginthus angolensis*	0	5		
	Green-winged Pytilia	*Pytilia melba*	4	0		
	Orange-winged Pytilia	*Pytilia afra*	1	0		
F	Red-throated Twinspot	*Hypargos niveoguttatus*	5	5		
	Red-billed Firefinch	*Lagonosticta senegala*	4	1		
	Pin-tailed Whydah	*Vidua macroura*	3	0		
	Total number of species		43	30		
	Total number of individuals		**263**	**135**		