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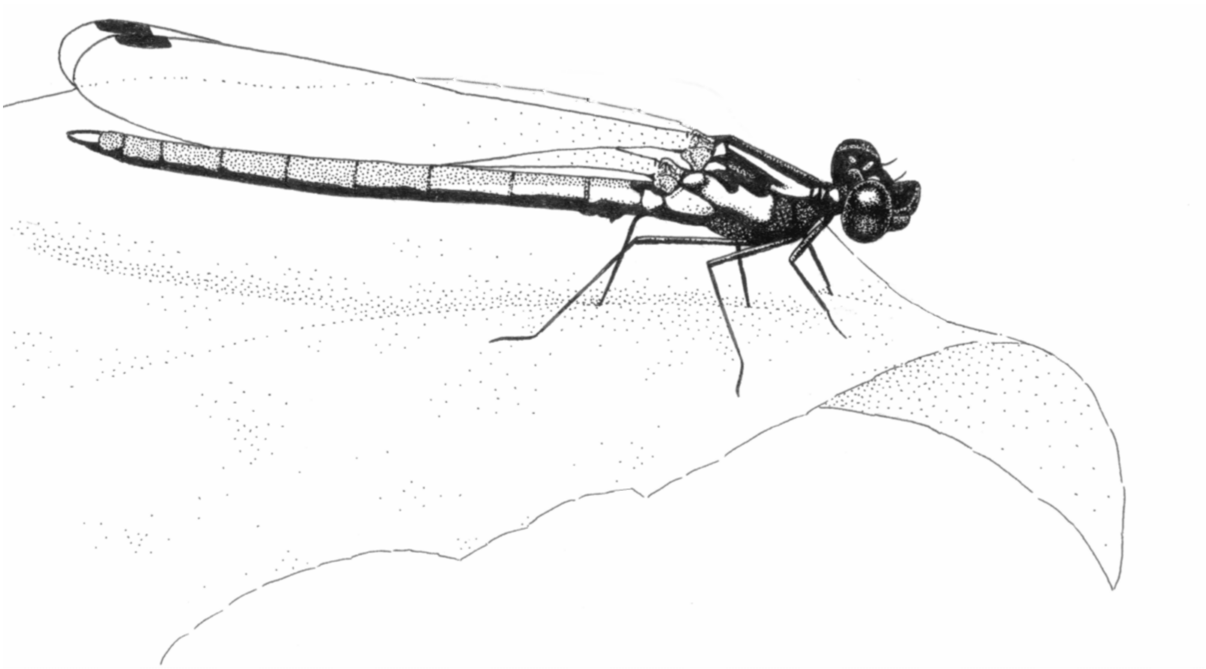

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Front cover: Chlorocypha tenuis*, a species of damselfly found in Kakamega Forest. Drawing by K.-D. B. Dijkstra.*

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THE AVIFAUNA OF A NATURALLY REGENERATING SECONDARY FOREST, PANGANI, NORTH-EASTERN TANZANIA

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ABSTRACT

As humans modify native ecosystems with increasing frequency, natural habitats including forests are lost. Under such circumstances, secondary forests can increasingly be important to conservation of biodiversity at landscape scales. However, in East Africa, little is known about avian community composition in regenerating secondary forests. In this study, avian diversity of a regenerating secondary forest was assessed in Pangani, northeastern Tanzania, using point counts. Sixty point counts were conducted for a duration of 12 days in about 90 ha of the regenerating secondary forest. Thirty species were found to utilise the regenerating secondary forest, of which 12 are categorized as forest-dependent species, and 12 were forest visitors. Using the same sampling effort in the adjoining riverine forest, there were 42 bird species, of which 11 and 13 were forest-dependent species and forest visitors, respectively. These results suggest that the regenerating secondary forest provided a habitat for a number of bird species including forest-dependent species and a few intra-African migrants, and it is thus of conservation value, at least at a local scale. Maintaining such regenerating secondary forests can provide greater landscape connectivity for the survival and, possibly, dispersal of birds.

Keywords: biodiversity recovery, bird diversity, coastal forest, forest-dependent birds

INTRODUCTION

In Tanzania, sisal *Agave sisalana* Perrine was planted (as a commercial crop) for the first time during the colonial era at Kikongwe, Pangani, north-eastern Tanzania in 1893 (Kimaro *et al.*, 1994). The first plantations in this area were established in 1900 (Hartemink & Wienk, 1995), and in order to do so, there was extensive clearing of vegetation (which was possibly coastal forest) 5–10 km inland from the Indian Ocean (Hemp, 2005). Houses to accommodate sisal plantation workers were built in the vicinity of the plantations and some naturally occurring tree species such as *Ficus* sp. were not cut down during house construction. Other trees such as *Terminalia catappa* L. and *Delonix regia* (Bojer ex Hook.) Raf. were planted in the neighbourhood. Retention (*e.g. Ficus* spp.) and planting of the tree species were for provision of shade, fencing, ornamentation and fruits.

Between the late 1980s and early 1990s people who had lived in these houses at Kikongwe, Pangani, moved out and the area was abandoned (Kalabwe Lumumwa, pers. comm.). In 1994 the management of the sisal company demolished the existing houses (Kalabwe Lumumwa, pers. comm.). Over time without further anthropogenic disturbances, other trees, particularly the exotic trees such as *Azadirachta indica* A.Juss., *Leucaena leucocephala* (Lam.) de Wit and *Cocos nucifera* L., as well as the native *Milicia excelsa* (Welw.) C.C.Berg, became established in the area. After more than 25 years the area has naturally regenerated to a secondary forest which could be a suitable habitat for some wildlife. The use of such a regenerating secondary forest (hereafter, a regenerating forest) by some faunal groups is important to the local and regional maintenance of biodiversity (*e.g.* birds) and the ecological roles they maintain (*e.g.* seed dispersal and pollination).

Such regenerating forests after intensive anthropogenic disturbances are uncommon in coastal Tanzania, and may be of value in conservation of biodiversity as well as provision of ecosystem services. While a number of avian studies have been conducted in coastal forests and thickets of Tanzania (Burgess *et al.*, 1991; Mlingwa, 1992, 1993; Mlingwa *et al.*, 1993; Jensen *et al.*, 2005; Wegner *et al.*, 2009), I am unaware of studies on the role of regenerating forests as habitats for birds in Tanzania. Thus, compared with natural forests, there is limited knowledge on the role of regenerating forests for bird conservation. In this study, I use birds to examine whether a naturally regenerating forest restores biodiversity as well as whether it can serve as a model to understand the impacts of land use changes on biodiversity. For comparison, sampling was also conducted in an adjoining riverine forest. This study is important given that there is increasing recognition that conservation of biodiversity needs to look beyond protected areas and include entire landscapes in order to maintain ecological processes (Boffa *et al.*, 2008). Additionally, given that loss of forests and intact woodlands is likely to continue (Tabor *et al.*, 2010), understanding the role of regenerating and secondary forests, such as the one in the study area, has potential to provide insights in how restored habitats aid in biodiversity recovery.

The main objective of this study was to evaluate the extent to which the regenerating forest provided a habitat for birds. Also, because bird species differ in their sensitivity to forest loss and disturbance, they were assessed in terms of their forest-dependence guilds (see Bennun *et al.*, 1996) as an additional way of evaluating the importance of the regenerating forest in accommodating forest-dependent species.

MATERIALS AND METHODS

Study area

The study area is located in Pangani District, north-eastern Tanzania, about 3.5 km west of the Indian Ocean (5°30'S, 38°56'E; figure 1). The regenerating forest that was sampled covers more than 90 ha and is currently protected by the management of a sisal plantation. In this forest there was little resource extraction that was observed. Tree species in this forest include native *Ficus* sp., *M. excelsa*, , and the exotics *T. catappa*, *D. regia*, *A. indica*, *C. nucifera* and *L. leucocephala*. Tree canopy cover ranges between 60–90% and the upper canopy height varies between 10–15 metres. In some places there is a closed understorey layer of native plant species including *Sorindeia madagascariensis* DC. whereas *L. leucocephala* dominates other locations. This regenerating forest is surrounded by sisal plantations to the north and west, and farmland and a disturbed riverine forest to the south and south-east (figure 1). The disturbed riverine forest, which adjoins the regenerating forest, has variable canopy cover (70–95%) and width. It is dominated by *Ficus* sp., *S. madagascariensis, Phoenix reclinata* Jacq., *Tamarindus indica* L. and *Acacia gerrardii* Benth. The riverine forest is mainly surrounded by thickets and the exotic, *L. leucocephala* as well as woodlands and wooded grasslands (figure 1). The thickets surrounding this forest are dominated by *Dichrostachys cinerea* (L.) Wight & Arn., *Piliostigma thonningii* (Schumach.) Milne-Redh. and *Hyphaene compressa* H.Wendl. To the east of the regenerating forest are disturbed coastal scrub and a few coastal thickets (figure 1). To the north-east of the sampled area is an extension of the area where there were houses (after they were demolished) which is now covered by regenerating secondary thickets (figure 1).

Methods

Birds were sampled using the fixed-radius point-count method (Bibby *et al.*, 2000). A total of 60 point counts were conducted in the regenerating forest. These were conducted from 17–21 June 2020 (26 point counts) after the end of the rainy season and from 9–15 October 2020 (34 point counts) during the dry season in this part of the country. Point counts were located at least 150 m from each other along point count transects. The point count transects were randomly laid down such that the entire area of the forest was sampled (see figure 1). Each point count was surveyed for a period of 10 minutes during the morning (07:00–11:00 h) and evening (16:00–18:00 h). Birds were recorded within a 30 m radius (Ndang'ang'a *et al.*, 2013). A similar method (using the same sampling effort) was used to record birds in the adjoining riverine forest in the same study period. The only difference was that point count transects were linear along the riverine forest (figure 1).

To assess whether sampling efforts in regenerating and riverine forests were adequate, rarefaction curves (species accumulation curves) were generated using a software package PAST: Paleontological Statistics Software Package (Hammer *et al.*, 2001). Because the total numbers of individuals of each species recorded in point counts were correlated with the number of point counts in which species were detected (*i.e.* maximum detections or frequencies of each species: in the regenerating forest, $r = 0.9796$, $p < 0.0001$; riverine forest, $r = 0.9185$, $p < 0.0001$), species abundances were expressed in terms of an abundance index. The abundance index for each species was calculated by dividing the maximum detections of a species (*i.e.* the maximum number of point counts at which a species was recorded) by the total number of point counts (*i.e.* 60 point counts) (Hutto, 2016; Hutto & Patterson, 2016).

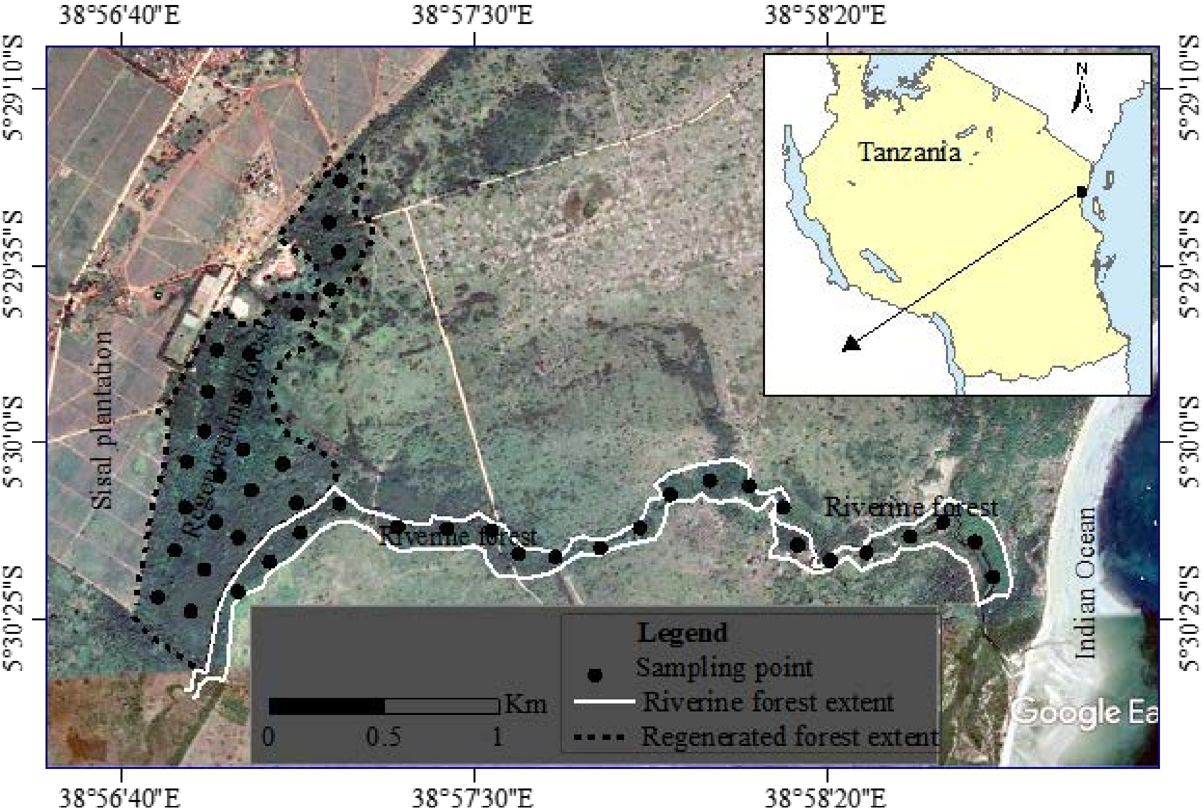

Figure 1. Map of the study area showing point count locations conducted in the regenerating forest (demarcated with black dashed line) and along the riverine forest (demarcated with solid white line), in Pangani, north-eastern Tanzania. Riverine forest occurs along the Demu River (Source: Google Earth).

While some species have intrinsic conservation interest because they are rare, endangered or endemic, some bird species can indicate forest (or habitat) condition and value (Bennun *et al.*, 1996). Thus the conservation significance of the regenerating forest was assessed based on its use by forest-dependent birds, which are especially sensitive to modifications of these habitats. The presence of forest-dependent species was assessed using Bennun *et al*. (1996) and Mlingwa *et al*. (2000). These were Forest Specialists (*FF* species) which are birds of the forest interior that are likely to disappear when the forest is modified. In contrast, Forest Generalists (*F* species) occur in undisturbed forests but are able to exist in modified and fragmented forests as well as forest edges. *F* species still depend upon the forest for some resources like nesting sites. Furthermore, the presence of forest visitors (*f* species) in each habitat was assessed using Bennun *et al*. (1996). Forest visitors (*f* species) are birds which are recorded in forest, but are not dependent upon it. They are commonly found in adjacent non-forest habitats. Forest dependency guild categorization was also undertaken for the birds observed in the adjoining riverine forest.

Common names and scientific names follow the International Ornithological Community World Bird Names v. 11.1 checklist (Gill *et al.*, 2020).

RESULTS

Regenerating forest

A total of 325 birds belonging to 30 species were recorded during the point counts. Among these were 12 forest-dependent species (1 *FF* species: 34 individuals; 11 *F* species: 168 individuals), and 12 species which were forest visitors (*f* species; 100 individuals) (table 1). The species accumulation curve showed an upward trend indicating that most of the species expected were observed, although the curve did not asymptote, suggesting that extra sampling would reveal a few more additional species (figure 2). The most common species in terms of abundance indices were red-capped robin-chat, collared sunbird, and olive sunbird (table 1).

*Table 1. Frequency of occurrence and relative abundance of bird species recorded in a regenerating secondary forest (Regen. forest) and riverine forest. FD = Forest dependence categories of specialist (FF) and generalist (F) following Bennun et al. (1996; see text for details), Max. det. (maximum detection) = highest frequency at hich a species was recorded. Ai = abundance index, which was calculated for each species by dividing the maximum detections (*i.e. *the maximum number of point counts a species was recorded in) by the total number of point counts (i.e. 60) (see text for details).*

		Regenerating forest		Riverine forest	
Common and species names	FD	Max. det.	Ai	Max. det.	Ai
Coqui francolin *Peliperdix coqui* (Smith, A, 1836)	-	0	0.00	1	1.67
Hadada ibis *Bostrychia hagedash* (Latham, 1790)	-	1	1.67	2	3.33
African harrier hawk *Polyboroides typus* Smith, A, 1829	f	2	3.33	1	1.67
Lizard buzzard *Kaupifalco monogrammicus* (Temminck, 1824)	f	2	3.33	0	0.00
Shikra *Accipiter badius* (Gmelin, JF, 1788)	f	0	0.00	1	1.67
Red-eyed dove *Streptopelia semitorquata* (Rüppell, 1837)	f	1	1.67	1	1.67
Emerald-spotted wood-dove *Turtur chalcospilos* (Wagler, 1827)	f	0	0.00	12	20.00
Tambourine dove *Turtur tympanistria* (Temminck, 1809)	F	5	8.33	3	5.00
White-browed coucal *Centropus superciliosus* Hemprich & Ehrenberg, 1829	-	1	1.67	3	5.00
Blue malkoha *Ceuthmochares aereus* (Vieillot, 1817)	F	2	3.33	16	26.67
Blue-naped mousebird *Urocolius macrourus* (Linnaeus, 1766)	-	0	0.00	1	1.67
Narina trogon *Apaloderma narina* (Stephens, 1815)	F	0	0.00	2	3.33
Broad-billed roller *Eurystomus glaucurus* (Statius Müller, PL, 1776)	f	1	1.67	0	0.00
Brown-hooded kingfisher *Halcyon albiventris* (Scopoli, 1786)	-	1	1.67	6	10.00
Striped kingfisher *Halcyon chelicuti* (Stanley, 1814)	-	0	0.00	1	1.67
African pygmy kingfisher *Ispidina picta* (Boddaert, 1783)	f	1	1.67	0	0.00
Common scimitarbill *Rhinopomastus cyanomelas* (Vieillot, 1819)	-	0	0.00	1	1.67
Crowned hornbill *Lophoceros alboterminatus* Büttikofer, 1889	f	2	3.33	0	0.00
Trumpeter hornbill *Bycanistes bucinator* (Temminck, 1824)	F	3	5.00	0	0.00
Yellow-rumped tinkerbird *Pogoniulus bilineatus* (Sundevall, 1850)	F	4	6.67	5	8.33
Red-fronted tinkerbird *Pogoniulus pusillus* (Dumont, 1805)	-	8	13.33	16	26.67
Spot-flanked barbet *Tricholaema lacrymosa* Cabanis, 1878	-	0	0.00	2	3.33
Brown-breasted barbet *Lybius melanopterus* (Peters, W, 1854)	-	0	0.00	3	5.00
Lesser honeyguide *Indicator minor* Stephens, 1815	f	0	0.00	2	3.33
Eastern black-headed batis *Batis minor* Erlanger, 1901	-	0	0.00	2	3.33
Black-throated wattle-eye *Platysteira peltata* Sundevall, 1850	F	1	1.67	0	0.00
Grey-headed bush-shrike *Malaconotus blanchoti* Stephens, 1826	-	0	0.00	1	1.67
Black-crowned tchagra *Tchagra senegalus* (Smith, A, 1836)	-	0	0.00	2	3.33
Black-backed puffback *Dryoscopus cubla* (Latham, 1801)	F	1	1.67	4	6.67
Black cuckooshrike *Campephaga flava* Vieillot, 1817	f	0	0.00	2	3.33
African golden oriole *Oriolus auratus* Vieillot, 1817	f	4	6.67	1	1.67
African paradise flycatcher *Terpsiphone viridis* (Statius Müller, PL, 1776)	f	12	20.00	10	16.67
Dark-capped bulbul *Pycnonotus tricolor* (Hartlaub, 1862)	f	16	26.67	33	55.00
Somber greenbul *Andropadus importunes* (Vieillot, 1818)	-	5	8.33	21	35.00
Terrestrial brownbul *Phyllastrephus terrestris* Swainson, 1837	F	8	13.33	14	23.33
Red-faced crombec *Sylvietta whytii* Shelley, 1894	-	1	1.67	0	0.00

Common and species names	FD	Regenerating forest		Riverine forest	
		Max. det.	Ai	Max. det.	Ai
Green-backed camaroptera *Camaroptera brachyuran* (Vieillot, 1821)	f	16	26.67	18	30.00
Rattling cisticola *Cisticola chiniana* (Smith, A, 1843)	-	0	0.00	1	1.67
Black-bellied starling *Notopholia corusca* (Nordmann, 1835)	F	0	0.00	7	11.67
Bearded scrub robin *Cercotrichas quadrivirgata* (Reichenow, 1879)	f	0	0.00	5	8.33
Ashy flycatcher *Muscicapa caerulescens* (Hartlaub, 1865)	F	1	1.67	1	1.67
White-browed robin-chat *Cossypha heuglini* Hartlaub, 1866	f	1	1.67	0	0.00
Red-capped robin-chat *Cossypha natalensis* Smith, A, 1840	F	39	65.00	16	26.67
Spotted palm thrush *Cichladusa guttata* (Heuglin, 1862)	-	0	0.00	1	1.67
Collared sunbird *Hedydipna collaris* (Vieillot, 1819)	F	25	41.67	23	38.33
Olive sunbird *Cyanomitra olivacea* (Smith, A, 1840)	FF	19	31.67	13	21.67
Grey sunbird *Cyanomitra veroxii* (Smith, A, 1832)	f	1	1.67	11	18.33
Amethyst sunbird *Chalcomitra amethystine* (Shaw, 1812)	f	0	0.00	1	1.67
Scarlet-chested sunbird *Chalcomitra senegalensis* (Linnaeus, 1766)	-	0	0.00	1	1.67
Red-throated twinspot *Hypargos niveoguttatus* (Peters, W, 1868)	F	6	10.00	0	0.00
Pied wagtail *Motacilla aguimp* Temminck, 1820	-	0	0.00	1	1.67

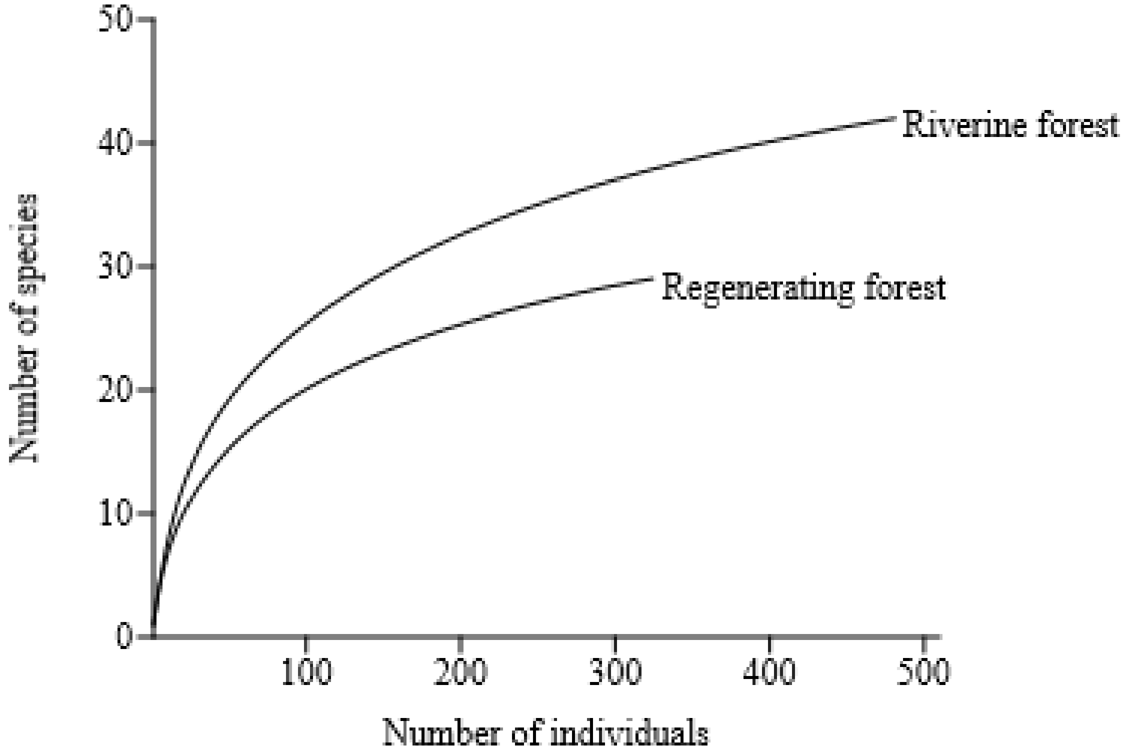

Figure 2. Species accumulation curves for the bird communities in the regenerating and riverine forests in Pangani, north-eastern Tanzania. These curves are based on the point count sampling.

Riverine forest

In total, 482 individuals of 42 species were observed (table 1). Among the species observed, 11 were forest-dependent species (1 *FF* species: 23 individuals; 10 *F* species: 202 individuals), and 13 species were forest visitors (*f* species: 160 individuals). The species accumulation curve in the riverine forest did not asymptote, suggesting that extra sampling would reveal few additional species (figure 2). The most common species in terms of abundance indices include the dark-capped bulbul , sombre greenbul and collared sunbird (table 1).

DISCUSSION

With a total of 30 species and 12 forest-dependent species, the forest avifauna of this regenerating forest is impoverished in comparison to those of remnant coastal forests (*e.g.*, Pande, Pugu and Kazimzumbwe; Burgess *et al.*, 1991; Mlingwa *et al.*, 1993) and coastal thickets (Mlingwa, 1992) in coastal Tanzania and Arabuko-Sokoke in coastal Kenya (Chiawo *et al.*, 2018). This impoverishment is reflected by the presence of few forest-dependent species compared with other coastal forests in Tanzania (*e.g.* Burgess *et al.*, 1991). This could be attributed to the presence of the exotic tree species in comparison with native tree species in coastal forests. Similarly, some avifauna impoverishment is expected in a small forest island like the regenerating forest as it was reflected in the small number of bird species recorded there. This agrees with the fact that smaller-sized forests tend to support a depauperate assemblage of species (Burgess & Mlingwa, 1993). Thus as a result of its small size, many coastal forest specialist bird species that should have occurred there were missing, probably because forest less than 10 km^2 tend to be too small to support many of the specialist forest species (see Burgess & Mlingwa, 1993).

A fairly higher proportion of individuals (62%) of forest-dependent species in the regenerating forest (n=12) may be due to the presence of large and tall trees (with high percentage of canopy cover) and a closed understorey layer. These results are similar to those of John & Kabigumila (2007, 2011) who found a number of forest-dependent bird species in *Eucalyptus* plantations with a good understorey layer of indigenous trees in the Usambara Mountains. Similarly, the importance of an understorey layer of indigenous trees was demonstrated by Cowley (1971) who found that birds move into pine plantations that maintain an indigenous understorey of suitable structure and composition. This suggests that patches of indigenous vegetation in the regenerating forest provide an adequate habitat for several forest-dependent bird species. The presence of large and tall trees in the regenerating forest with a canopy cover ranging between 60–90%, matches the findings of Naidoo (2004) who found that forest birds prefer areas with high tree cover. Similarly, as supported by Laube *et al.* (2008) who found that species richness of forest birds was high in areas with high vertical vegetation heterogeneity, the same type of vegetation complexity in the regenerating forest likely attracted forest birds. Furthermore, the presence of a number of ecologically important tree species, such as *Ficus* sp., could have attracted some species such as the trumpeter hornbill, which was observed feeding on *Ficus* fruits in October. Tree species in the genus *Ficus* are important in the diets of many tropical mammals and birds (Shanahan *et al.*, 2001), and reported to constitute a large proportion of the diet for more vertebrate species than any other fleshy fruits (see Lambert, 1989; Shanahan *et al.*, 2001).

The presence of forest-dependent species in this regenerating forest suggests that it is of conservation value at a local level (see Burgess *et al.*, 1991). The study further demonstrates that even some forest-dependent species can survive in secondary forests, and that this is more likely if other forest habitats, such as the adjoining riverine forest (in the study area), exist nearby (see Dranzoa *et al.*, 2011). Thus in the study area, the adjoining riverine forest which had 11 forest-dependent species (of which it shared nine species with the regenerating forest) could have been a source habitat for the forest-dependent species as well as forest visitors which were observed in the regenerating forest (see table 1).

Results of the present study advocate for a landscape matrix approach to conservation which allows habitat connectivity, foraging opportunities and possible dispersal of bird species. This approach can enhance ecological quality of the landscape matrix and provide habitat and greater landscape connectivity through buffer zones, corridors and stepping stones for dispersal of plant and animal species (Perfecto & Vendermeer, 2002). Thus the results suggest that the regeneration forest can provide dispersal routes and could be important for creating corridors between primary forests. This is supported by the fact that some species observed in the regenerating forest have dispersal abilitites. For example, tambourine dove and olive sunbird (Korfanta *et al.*, 2012), and trumpeter hornbill (Stuart, 1983) have been found to move between forest fragments in the Usambara Mountains. Elsewhere, in Taita Hills, Kenya, an olive sunbird was ringed on 12 February 1997 in Chawia and was recaptured on 6 March 1997 in Mbololo, covering a distance of about 18 km (Department of Ornithology, 1997).

Forest visitors observed in the regenerating forest most likely dispersed from adjoining habitats, such as the riverine forest, regenerating secondary thickets and disturbed savanna to the east and north-east of the regenerating forest (see table 1). These results are similar to those of Estrada *et al.* (1997), Naidoo (2004) and Laube *et al.* (2008) who found that bird diversity tends to be higher in forests surrounded by a variety of other types of matrix habitats from which birds can then disperse into forest.

Some species observed to utilise the regenerating forest are well known intra-African migrants. These include the red-capped robin-chat which has been reported to be locally abundant in coastal Kenya from May to October but largely absent between December and April (Turner & Backhurst, 2020). It is probable that the red-capped robin-chat utilises this area between May and October, the period during which the study was conducted. Other intra-African migrants observed were broad-billed roller, African pygmy kingfisher, African golden oriole and African paradise flycatcher (Turner & Backhurst, 2020). These results suggest that the regenerating forest is also a habitat for some Afrotropical migrants (see Turner & Backhurst, 2020).

While the study was limited by a proper assessment of habitat structure and lack of a comparable natural forest of similar size, the results suggest that the regenerating forests dominated by exotic plant species and a closed understorey layer can support some avian diversity. The avian diversity in this context include forest-dependent species and forest visitors whose numbers were almost the same as that of the adjoining riverine forest. This observation is in line with the findings of John & Kabigumila (2011) and Werema & Howell (2015) who reported that plantations of exotic trees, with regenerating native vegetation, can have potential value to some bird species of conservation concern. Specifically, in a landscape context, results from this study suggest allowing habitats to naturally regenerate next to the adjoining forests may help forest biodiversity to recover.

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