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The avifauna of four lower Tana River forest fragments: A preliminary survey

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m from the ground. For each count, each species was scored according to when it was first recorded (4 if in the first ten minutes, 3 if in the next ten minutes and so on). The scores were then averaged over all counts to give a simple

relative abundance index.

In addition to the counts, general observations were made at any time.

Table 1. Mist-netting effort at four fragments in Tana River Primate Reserve

Site	Dates	Area (ha)	Net length (m)	Hours	Total m h
Mchelelo	20-21/2/99	63	105	8.40	882
Mnazini South	22-23/2/99	50	100	9.10	910
Mnazini North	24-25/2/99	38	100	9.05	905
Congolani Central	26-27/2/99	50	100	9.10	910

Vegetation surveys

We walked along randomly-selected directions in the forests and marked 40 points at intervals of 20 m. At each point, canopy height was estimated to the nearest 1 m and canopy cover was visually estimated as a percentage. Shrub density was measured by using a square chequered board of 40 cm x 40 cm divided into 8 cm x 8 cm black or white squares. We counted the number of squares visible at 1 m and 2 m height at points fixed 5 m north and south of the observer standing from the 40 chosen points (a modification of the half-sight measurement technique: Brooks *et al.*, in prep).

Two plots (1 m x 1 m) were also established on the north and south compass bearings at a distance of 5 m from the point. In each plot, percentage herb and litter cover and bare ground were visually estimated. All vegetation measures were averaged for each forest patch and analysis of variance followed by Student-Newman-Keuls multiple range tests

(SuperAnova v. 1.11, Abacus Concepts 1991) used to assess structural differences among the fragments.

Categorisation of birds

Forest-dependence categories follow Bennun *et al.* (1996) who recognised three categories of forest birds:

- (1) 'FF species' (forest specialists) are true forest birds, characteristic of the interior of undisturbed forest;
- (2) 'F species' (forest generalists) may occur in undisturbed forest but are also regularly found in forest strips, edges and gaps;
- (3) 'f species' (forest visitors) are birds which are often recorded in the forest but are not dependent upon it.

Global threat categories follow Collar *et al.* (1994), regional threat categories follow Bennun & Njoroge (1996), and birds characteristic of the East African Coast biome follow the list in Fishpool (1996).

Results

Species list

Table 2 shows the overall list of forest species recorded at the four study areas, classified according to forest-dependence and threat. In total, 55 species were recorded, including six forest specialists (FF), 25 forest generalists (F), 19 forest visitors (f) and five non-forest species (s). The 50 forest birds represent 59.5% of the 84 species listed by Mlingwa *et al.* (in press). Eight species of the East African Coast biome were recorded, out of 20 known from the area (though only ten of these 20 are forest-dependent birds). There were records of two globally near-threatened species (Southern Banded Snake Eagle *Circaetus fasciolatus* and

Fischer's Turaco *Tauraco fischeri*) and two regionally-threatened species (the regionally Vulnerable Ayres's Hawk Eagle *Hieraaetus ayresii* and Little Yellow Flycatcher *Erythrocerus holochlorus*). Notably absent were two Red Data Book forest species, the East Coast Akalat *Sheppardia gunningi* (Vulnerable) and Plain-backed Sunbird *Anthreptes reichenowi* (Near-threatened). Also missing were the two species of helmet-shrikes recorded in the Tana River forests (Retz's Red-billed *Prionops retzii* and Chestnut-fronted *P. scopifrons*), both normally noisy and conspicuous species.

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Introduction

The Tana River Primate National Reserve (1°55'S, 40°5'E) is located along the lower reaches of the Tana River in Tana River District (Butynski and Wahungu 1994). It covers 169 km² of which around 11 km² is riverine forest. The reserve contains a wide variety of habitats, ranging from cultivation and open dry bushland to woodland and several distinct forest types. These forests, occurring patchily on each side of the river, are listed among the key forests for bird conservation in Africa (Collar & Stuart 1988). The avifauna includes many species confined to coastal forests in East Africa, among them several that are globally threatened or near-threatened bird. The nominate race of the threatened White-winged *Apalis Apalis chariessa* is known only from here, where it has been recorded just once this century, in 1961. The forest also shelters two endangered primate sub-species, the Tana River Red Colobus *Colobus badius rufomitratu*s and

Tana River Mangabey *Cercocebus galeritus galeritus*. The Lower Tana river forests are recognised as an Important Bird Area (Bennun & Njoroge, in press).

Information on the avifauna of the Lower Tana forests is patchy and scant. Apart from some general surveys in the 1970s (Andrews *et al.* 1975, Marsh *et al.* 1975) there has been little systematic ornithological work here. Butynski (1994) reported on the presence of Uluguru Violet-backed Sunbird *Anthreptes neglectus* in the forests, and the Mlingwa *et al.* (in press) summarised the existing species list. The avifauna of the different forest types has not been characterised, and it is not known which of the sites or the succession stages are the most important for bird conservation. As an initial step towards understanding the avifauna better, we conducted a rapid survey of birds in four of the Tana River Primate Reserve forests between 20 and 26 February 1999, paying special attention to threatened species and coastal forest endemics.

Sites and methods

Study areas

Avifaunal surveys and vegetation assessments were made in four forest patches within the Tana River Primate Reserve: Mchelelo (63 ha), Mnazini South (50 ha), Mnazini North (38 ha) and Congolani Central (50 ha) (areas from Butynski & Wahungu, 1994). The forest patches are separated by farmland, open dry bushland and river scars. These areas were chosen because they were relatively secure and accessible, and only a short time was available for the surveys.

Weather

The weather was dry during our visit, usually being cool in the early morning but clear, sunny and hot by mid-morning.

Avifaunal surveys

At each study site, birds were surveyed by a combination of mist-netting, timed species-counts and general observations. At each site, we cleared a narrow trail, 100 m long, through the understorey vegetation. We then erected a

line of small mesh, 3-m high mist-nets (100 m in total) which were operated for two mornings each. Nets were opened as soon as possible after dawn, between 06:30 and 07:30 h depending on the availability of security. Nets were closed between 11:10 and 11:40 hours. Mist-netting effort is summarised in Table 1.

Timed species-counts were conducted each morning, simultaneously with mist-netting. Counts were made along open spaces in the understorey or footpaths where available. The procedure followed Bennun & Waiyaki (1993). Every time a new bird species was detected during a count, the time was recorded, together with an indication whether the detection was by sight or sound, whether the bird was within 25 m of the observer and, if so, whether it was above 3 m from the ground. Each count was 40 minutes long. A total of 12 counts were conducted in each study area.

Relative abundance indices for canopy/mid-level species were calculated using only records for birds detected within 25 m of the observer and above 3

Species	Status	Mchel	Mnz N.	Mnz S.	Cong
Pycnonotidae					
Little Greenbul <i>Andropadus virens</i>	F	x	-	x	-
Zanzibar Sombre Greenbul <i>Andropadus importunus</i>	s	-	x	x	x
Yellow-bellied Greenbul <i>Chlorocichla flaviventris</i>	F	x	-	-	x
Fischer's Greenbul <i>Phyllastrephus fischeri</i>	FC	x	x	x	x
Northern Brownbul <i>Phyllastrephus strepitans</i>	fC	x	-	-	-
Terrestrial Brownbul <i>Phyllastrephus terrestris</i>	F	x	x	x	-
Turdidae					
E. Bearded Scrub Robin <i>Cercotrichas quadrivirgata</i>	f	x	x	-	x
Red-capped Robin Chat <i>Cossypha natalensis</i>	F	x	x	x	x
Red-tailed Ant Thrush <i>Neocossyphus rufus</i>	FF	x	x	x	x
Muscicapidae					
Ashy Flycatcher <i>Muscicapa caerulescens</i>	F	-	-	-	x
Sylviidae					
Black-headed Apalis <i>Apalis melanocephala</i>	FF	x	x	x	-
Grey-backed Camaroptera <i>Camaroptera brachyura</i>	f	x	-	x	x
Monarchidae					
Little Yellow Flycatcher <i>Erythrocerus holochlorus</i>	FFCvu	-	x	x	-
African Paradise Flycatcher <i>Terpsiphone viridis</i>	f	x	x	x	x
Blue-mantled Cr. Flycatcher <i>Trochocercus cyanomelas</i>	FF	x	x	-	-
Platysteiridae					
Pale Batis <i>Batis soror</i>	FC	-	x	-	-
Black-throated Wattle-eye <i>Platysteira peltata</i>	F	-	x	-	-
Malaconotidae					
Black-backed Puffback <i>Dryoscopus cubla</i>	F	x	x	x	-
Tropical Boubou <i>Laniarius ferrugineus</i>	f	x	x	x	x
Dicruridae					
Square-tailed Drongo <i>Dicrurus ludwigii</i>	F	x	x	x	x
Oriolidae					
Black-headed Oriole <i>Oriolus larvatus</i>	f	-	x	x	x
Sturnidae					
Black-bellied Starling <i>Lamprotornis corruscus</i>	FC	x	x	x	x
Nectariniidae					
Collared Sunbird <i>Anthreptes collaris</i>	F	x	x	x	x
Olive Sunbird <i>Nectarinia olivacea</i>	FF	x	x	x	x
Ploceidae					
Dark-backed Weaver <i>Ploceus bicolor</i>	F	x	x	x	x
Spectacled Weaver <i>P. ocularis</i>	s	x	x	-	-
Black-headed Weaver <i>P. cucullatus</i>	s	x	x	x	x

Key: Mchel., Mchelelo; Mnz S., Mnazini South; Mnz N., Mnazini North; Cong. C., Congolani Central; FF, forest-specialist species; F, forest-generalist species; f, forest visitors; s, savanna/woodland species; Nt, globally near-threatened species; vu, regionally Vulnerable species; C, East Coast Biome species.

Table 2. Forest birds recorded in the four study areas

Species	Status	Mchel	Mnz N.	Mnz S.	Cong
Accipitridae					
Southern Banded Snake Eagle <i>Circaetus fasciolatus</i>	FCNt	-	-	-	x
Little Sparrowhawk <i>Accipiter minullus</i>	f	-	-	x	-
African Goshawk <i>Accipiter tachiro</i>	F	x	x	x	-
Ayres's Hawk Eagle <i>Hieraaetus ayresii</i>	Fvu	x	-	-	-
Lizard Buzzard <i>Kaupifalco monogrammicus</i>	f	-	-	x	-
Numididae					
Crested Guineafowl <i>Guttera pucherani</i>	F	x	-	x	x
Columbidae					
Red-eyed Dove <i>Streptopelia semitorquata</i>	f	-	x	x	-
Tambourine Dove <i>Turtur tympanistria</i>	F	-	-	x	x
African Green Pigeon <i>Treron calva</i>	F	-	x	x	-
Musophagidae					
Fischer's Turaco <i>Tauraco fischeri</i>	FCNt	-	-	x	x
Cuculidae					
Thick-billed Cuckoo <i>Pachycoccyx audeberti</i>	f	-	-	x	-
Strigidae					
African Wood Owl <i>Strix woodfordii</i>	F	x	-	-	-
African Barred Owlet <i>Glaucidium capense</i>	F	x	-	-	-
Trogonidae					
Narina Trogon <i>Apaloderma narina</i>	F	x	x	-	-
Alcedinidae					
Grey-headed Kingfisher <i>Halcyon leucocephala</i>	f	x	x	x	x
Brown-hooded Kingfisher <i>H. albiventris</i>	s	x	x	x	x
African Pygmy Kingfisher <i>Ispidina picta</i>	f	x	x	-	x
Meropidae					
White-throated Bee-eater <i>Merops albicollis</i>	f	x	-	x	x
Coraciidae					
Broad-billed Roller <i>Eurystomus glaucurus</i>	f	-	-	x	x
Phoeniculidae					
Green Wood-hoopoe <i>Phoeniculus purpureus</i>	s	x	-	x	x
Bucerotidae					
Trumpeter Hornbill <i>Bycanistes bucinator</i>	F	-	x	x	-
Crowned Hornbill <i>Tockus albiterminatus</i>	f	x	-	x	x
Capitonidae					
Black-collared Barbet <i>Lybius torquatus</i>	f	x	-	-	-
Yellow-rumped Tinkerbird <i>Pogoniulus bilineatus</i>	F	x	x	-	-
Indicatoridae					
Lesser Honeyguide <i>Indicator minor</i>	f	x	-	-	-
Picidae					
Bearded Woodpecker <i>Thripias namaquus</i>	f	x	-	-	-
Green-backed Woodpecker <i>Campethera cailliautii</i>	f	x	x	x	-

Table 4. Bird species ringed in Mchelelo, in order of abundance

Species	Status	No. caught	Index ¹	Rank
Red-capped Robin Chat	F	19	21.5	1
Fischer's Greenbul	FC	12	13.6	2
Olive Sunbird	FF	4	4.5	3
African Pygmy Kingfisher	f	3	3.4	4
Red-tailed Ant Thrush	FF	3	3.4	4
Blue-mantled Crested Flycatcher	FF	2	2.3	5
Brown-hooded Kingfisher	s	2	2.3	5
Square-tailed Drongo	F	2	2.3	5
Eastern-bearded Scrub Robin	f	2	2.3	5
African Barred Owlet	F	1	1.3	6
Terrestrial Brownbul	F	1	1.3	6
African Goshawk	F	1	1.3	6
Northern Brownbul	fC	1	1.3	6

¹Birds caught per 1000 m h of netting. Status codes as in Table 2.

Table 5. Bird species ringed in Mnazini South, in order of abundance

Species	Status	No. caught	Index ¹	Rank
Olive Sunbird	FF	4	4.4	1
Red-capped Robin Chat	F	3	3.3	2
Red-tailed Ant Thrush	FF	3	3.3	2
Fischer's Greenbul	FC	2	2.2	3
Brown-hooded Kingfisher	s	2	2.2	3
Terrestrial Brownbul	F	2	2.2	3
Square-tailed Drongo	F	1	1.1	4
Zanzibar Sombre Greenbul	s	1	1.1	4

¹Birds caught per 1000 m h of netting. Status codes as in Table 2.

Table 6. Bird species ringed in Mnazini North, in order of abundance

Species	Status	No. caught	Index ¹	Rank
Fischer's Greenbul	FC	7	7.7	1
Red-capped Robin Chat	F	6	6.6	2
Olive Sunbird	FF	5	5.5	3
Eastern-bearded Scrub Robin	f	3	3.3	3
Terrestrial Brownbul	F	3	3.3	4
African Pygmy Kingfisher	f	2	2.2	5
Blue-mantled Crested Flycatcher	FF	2	2.2	5
Red-tailed Ant Thrush	FF	1	1.1	6
Black-throated Wattle-eye	F	1	1.1	6
Narina Trogon	F	1	1.1	6

¹Birds caught per 1000 m h of netting. Status codes as in Table 2.

Table 7. Bird species ringed in Congolani Central, in order of abundance

Species	Status	No. caught	Index ¹	Rank
Red-capped Robin Chat	F	12	13.2	1
Olive Sunbird	FF	9	9.9	2
Red-tailed Ant Thrush	FF	5	5.5	3
African Pygmy Kingfisher	f	3	3.3	4
Brown-hooded Kingfisher	s	3	3.3	4
Eastern Bearded Scrub Robin	f	2	2.2	5

¹Birds caught per 1000 m h of netting. Status codes as in Table 2.

The results for each forest patch are summarised in Table 3. The highest number of species was recorded in Mchelelo (38), followed by Mnazini South (36), Mnazini North (31) and Congolani Central (29). Mchelelo also held the highest number of forest-dependent species. The highest proportion of forest-dependent species was in Mnazini North. Congolani

Central had both the lowest number and the lowest proportion of forest-dependent species.

Four non-forest species, Brown-hooded Kingfisher *Halcyon albiventris*, Green Wood-hoopoe *Phoeniculus purpureus*, Spectacled Weaver *Ploceus ocularis* and Black-headed Weaver *Ploceus cucullatus*, were recorded at all sites.

Table 3. Summary of bird species recorded from the four study areas

	Mchelelo	Mnazini South	Mnazini North	Congolani Central
No. species	38	36	31	29
FF species	4	4	4	2
% FF species	10.5	11.1	12.9	6.9
F species	17	15	15	12
% F species	44.7	41.7	48.4	41.4
Forest-dependent species	21	19	19	14
% forest-dependent species	55.2	52.8	61.3	48.3
f species	13	13	8	10
% f species	34.2	36.1	25.8	34.5
s species	4	4	4	5
% s species	10.5	11.1	12.9	17.2

Status codes as in Table 2.

Mist-netting results

The results of mist-netting work are given in Table 4-7, and summarised in Table 8. Red-capped Robin Chat *Cossypha natalensis* (a forest generalist) was common in Mchelelo where the rate of capture was remarkably high (21.5 birds/1000 m h). This species was also common at Congolani Central (13.2 birds/1000 m h), and moderately common at Mnazini South and North where it ranked second in abundance, though with low capture rates (3.3 birds/1000 m h and 6.6 birds/1000 m h respectively).

Fischer's Greenbul *Phyllastrephus fischeri*, a forest-specialist (FF) species, was common at Mnazini North where it was the most abundant species (7.7 birds/1000 m h), and it was the second most abundant species at Mchelelo. Its numbers were low at Mnazini South and it was not captured at Congolani Central. Olive Sunbird *Nectarinia olivacea* (FF) was common at Mnazini South and fairly common in all other areas. Red-tailed Ant Thrush *Neocossyphus rufus* (also FF) was fairly common in all areas, but less abundant at Mnazini North than elsewhere. African Pygmy

Kingfisher *Ispidina picta* was fairly common at Mchelelo and Congolani Central, rare at Mnazini North, and absent at Mnazini South. Eastern Bearded Scrub Robin *Cercotrichas quadrivirgata* was commonest at Mnazini North, rarer at Mchelelo and Congolani Central and absent in Mnazini South. Terrestrial Brownbul *Phyllastrephus terrestris* was rare at all sites and absent at Congolani Central.

Overall, captures were highest at Mchelelo (53), followed by Congolani Central (33) and Mnazini South (31). Few birds were captured at Mnazini North (18). The proportion of forest-dependent birds captured was similar at Mchelelo (84.9%), Mnazini North (83.9%) and Mnazini South (83.3%), but somewhat lower at Congolani Central (76.5%).

Species richness was highest in Mchelelo and lowest at Congolani. Nine forest-dependent species were caught at Mchelelo (69.3%), eight at Mnazini North (80.0%), six at Mnazini South (75.0%) and only three at Congolani Central.

Table 10. Results for timed species counts at Mnazini South (n=12).

Species-	Status	Index	Rank
Olive Sunbird	FF	0.73	1
Dark-backed Weaver	F	0.67	2
Square-tailed Drongo	F	0.67	2
Grey-headed Kingfisher	f	0.42	3
Green Wood Hoopoe	s	0.35	4
African Green Pigeon	F	0.33	5
Green-backed Woodpecker	f	0.21	6
Black-headed Apalis	FF	0.19	7
Crowned Hornbill	f	0.17	8
Little Greenbul	F	0.15	9
Brown-hooded Kingfisher	s	0.15	9
Collared Sunbird	F	0.13	10
Black-backed Puffback	F	0.08	11
Black-bellied Starling	FC	0.08	11
Little Yellow Flycatcher	FFCvu	0.08	11
African Goshawk	F	0.08	11
Lizard Buzzard	f	0.08	11
Thick-billed Cuckoo	f	0.08	11
Black-headed Weaver	s	0.06	12
African Paradise Flycatcher	f	0.06	12
White-throated Bee-eater	f	0.06	12
Fischer's Greenbul	FC	0.06	12
Black-headed Oriole	f	0.06	12
Little Sparrowhawk	f	0.06	12
Red-eyed Dove	f	0.04	13

Only data for birds recorded above 3 m and within 20 m are included.
Status codes as in Table 2.

Table 11. Results for timed species-counts at Mnazini North (n=12)

Species	Status	Index	Rank
Olive Sunbird	FF	1.37	1
Black-headed Apalis	FF	0.48	2
Square-tailed Drongo	F	0.33	3
Fischer's Greenbul	FC	0.33	3
Dark-backed Weaver	F	0.23	4
Brown-hooded Kingfisher	s	0.21	5
Red-eyed Dove	f	0.19	6
African Paradise Flycatcher	f	0.17	7
African Green Pigeon	F	0.17	7
Narina Trogon	F	0.13	8
Black-headed Weaver	s	0.10	9
Black-headed Oriole	f	0.08	10
Trumpeter Hornbill	F	0.07	11
Black-bellied Starling	FC	0.06	12
Collared Sunbird	F	0.06	12
Black-backed Puffback	F	0.04	13
Grey-headed Kingfisher	f	0.02	14
Spectacled Weaver	s	0.02	14
Green-backed Woodpecker	f	0.02	14
Little Yellow Flycatcher	FFCvu	0.02	14
African Goshawk	F	0.02	14

Only data for birds recorded above 3 m and within 20 m are included.
Status codes as in Table 2.

Table 8. Summary of ringing results for the four study areas.

	Mchelelo	Mnazini South	Mnazini North	Congolani Central
No. captured	53	18	31	33
Capture rate/1000 m h	882	910	905	910
No. species	13	8	10	6
No. FF species	3	2	3	2
% FF species	23.1	25.0	30.0	33.3
No. F species	6	4	5	1
% F species	46.2	50.0	50.0	16.7
No. of f species	3	-	2	2
% f species	23.1	-	20.0	33.3
s species	1	2	-	1
% s species	7.7	25.0	-	16.7
No. C species	2	1	1	-
% C	15.4	12.5	10.0	-

Status codes as in Table 2.

Timed species-counts (TSCs)

Results of the timed species-counts are given in Table 9-12.

Olive Sunbird was the highest-ranking species in all the four forests. Square-tailed Drongo *Dicrurus ludwigii* and Dark-backed Weaver *Ploceus bicolor* were common everywhere. Black-headed Apalis *Apalis melanocephala* was considerably more abundant at Mnazini North and Mchelelo than at Mnazini South, and was absent at Congolani Central.

At Congolani Central, White-throated Bee-eater *Merops albicollis* was the second most abundant species. This species was fairly common in Mchelelo, less so at Mnazini South, and absent at Mnazini North. Collared Sunbird *Anthreptes collaris* was considerably more abundant at Mchelelo and Congolani Central than the other two areas.

Table 9. Results for timed species-counts at Mchelelo (n=12)

Species	Status	Index	Rank
Olive Sunbird	FF	1.40	1
African Paradise Flycatcher	f	0.65	2
Collared Sunbird	F	0.65	2
Dark-backed Weaver	F	0.56	3
Square-tailed Drongo	F	0.42	4
Black-headed Apalis	FF	0.35	5
White-throated Bee-eater	f	0.31	6
Bearded Woodpecker	f	0.21	7
African Pygmy Kingfisher	f	0.21	7
Spectacled Weaver	f	0.21	7
Grey-headed Kingfisher	f	0.17	8
Black-headed Weaver	s	0.15	9
Yellow-rumped Tinkerbird	F	0.15	9
Fischer's Greenbul	FC	0.13	10
Black-backed Puffback	F	0.08	11
Green Wood Hoopoe	s	0.08	11
Little Greenbul	F	0.08	11
Green-backed Woodpecker	f	0.08	11
Black-bellied Starling	FC	0.06	12
Ayres's Hawk Eagle	Fvu	0.04	13
Lesser Honeyguide	f	0.04	13
Narina's Trogon	F	0.04	13
Crowned Hornbill	f	0.02	14

Only data for birds recorded above 3 m and within 20 m are included. Status codes as in Table 2.

Discussion

All four patches supported a moderately rich avifauna that is characteristic of coastal forests. However, the proportion of forest-dependent species and individuals is lower than in many Kenyan forests (cf. Bennun & Fanshawe 1997). This is not surprising, given that these forest patches are all small and surrounded by non-forest habitats. Nonetheless, this is also an indication of forest disturbance (Bennun & Fanshawe 1997). On this basis, it appears that all the forest patches are highly disturbed — which is further borne out by the vegetation structure

measurements (see below) and the absence of several key forest-dependent species, such as East Coast Akalat, Plain-backed Sunbird and Uluguru Violet-backed Sunbird.

The forests can be ranked in terms of the number and proportion of forest-dependent birds (Table 14). This suggests that Mchelelo has the most intact avifauna, followed by Mnazini North and Mnazini South. Congolani Central consistently ranked the lowest, suggesting that its avifauna is the most characteristic of disturbed forest.

Table 14. The four forest patches ranked according to five measures that indicate forest disturbance. Ranks are from 1 (most intact) to 4 (most disturbed), based on data in Tables 3 and 8

Variable	Rank			
	Mchelelo	Mnazini North	Mnazini South	Congolani Central
No. forest-dependent spp. recorded	1	2.5	2.5	4
% forest-dependent spp. recorded	2	3	1	4
No. forest-dependent spp. captured	1	2	4	3
% captured individuals that are forest-dependent	1	2	3	4
No. forest-dependent spp. captured	1	2	3	4
Mean rank	1.2	2.3	2.7	3.8

While many bird species occurred at all sites, their abundances often differed greatly. This suggests that there are strong local effects of forest structure, which will depend both on the degree and type of disturbance and on the patch's successional history. Some species, such as Little Yellow Flycatcher, were patchily distributed, apparently absent from one or more patches altogether. These species may be the most sensitive to particular structural changes, and therefore absent from certain patches that do not meet their requirements. Alternatively they may be distributed across fragments as a meta-population, with local extinction and recolonisation over time. These forest patches are individually far too small to support viable populations of any bird species, and there is presumably considerable movement between them. This implies that it is important for biodiversity conservation to maintain a large set of more-or-less interconnected fragments.

The vegetation measures suggested that all the forests were disturbed, with only moderate canopy cover of 41–62%. Canopy height and cover have been shown to be important structural variables for many forest-dependent birds (Fanshawe 1995, Matiku 1996, Kosgey 1998). The two 'best' forests in terms of their

avifauna, Mchelelo and Mnazini North, were also 'best' in terms of their canopy cover. Mnazini North also showed a significantly higher canopy than the other forests. The understorey variables were more difficult to interpret: Mchelelo showed the thickest understorey and the most herb cover, aspects usually associated with disturbance. However, the structural effects of disturbance at this level are complex and vary according to forest type (Fanshawe 1995, Bennun & Fanshawe 1997, Nemeth 1996). Also, vegetation data are usually noisy, and 40 samples may not be sufficient to demonstrate moderate structural differences clearly.

Signs of current human disturbance — honey harvesting, canoe construction and pole-cutting — were obvious at Mnazini North and South and Congolani Central. Our results suggest that these could be having a substantial impact on forest bird communities. The threatened East Coast Akalat, which is known to be particularly sensitive to habitat modification (Matiku 1996, Nemeth 1996), was absent from all the four forests we surveyed. A more extensive survey, involving additional patches, is needed to understand properly the effects of disturbance on the birds of these important forests.

Table 12. Results of timed species-count at Congolani Central (n=12)

Species	Status	Index	Rank
Olive Sunbird	FF	1.54	1
White-throated Bee-eater	f	0.21	2
Square-tailed Drongo	F	0.17	3
Collared Sunbird	F	0.17	3
Dark-backed Weaver	F	0.13	4
Black-headed Oriole	f	0.13	4
Black-bellied Starling	FC	0.08	5
Black-headed Weaver	s	0.06	6
Brown-hooded Kingfisher	s	0.06	6
Tambourine Dove	F	0.06	6
Green Wood Hoopoe	s	0.06	6
Grey-headed Kingfisher	f	0.04	7
Fischer's Greenbul	FC	0.04	7
Fischer's Turaco	FCNt	0.04	7
African Paradise Flycatcher	f	0.02	8
Ashy Flycatcher	F	0.02	8

Only data for birds recorded above 3 m and within 20 m are included. Status codes as in Table 2.

Vegetation structure

The means of seven vegetation variables measured are presented for each fragment in Table 13. In terms of canopy cover, Mnazini North and Mchelelo showed significantly better condition than the other fragments. The canopy height in Mnazini North was also significantly greater than in the other sites. In the

understorey, Mchelelo showed a less open structure (with fewer squares visible at 1 m and 2 m height) and a lower percentage of leaf cover on the ground than the other sites. Mchelelo showed less, and Mnazini South more, bare ground than the other sites; while Mnazini South also showed substantially less herb cover.

Table 13. Mean values (\pm standard deviations) of vegetation variables in the surveyed forest fragments, and ANOVA results for differences in the means across fragments. Mean values that have the same letter are not significantly different (at the 5% level) on a Student-Newman-Keuls test

Variable	Mchelelo	Mnazini North	Mnazini South	Congolani Central	ANOVA results
Canopy height (m)	17.7 \pm 11.2 a	23.1 \pm 8.9 a	16.9 \pm 7.8 b	16.2 \pm 8.5 b	$F_{3,155} = 4.2^{**}$
Canopy cover (%)	51.3 \pm 32.3 b	61.8 \pm 24.1 a	40.9 \pm 22.8 b	46.0 \pm 29.1 b	$F_{3,155} = 4.6^{**}$
Shrub density at 1 m ht (no. squares uncovered)	15.1 \pm 9.4 a	18.7 \pm 7.3 b	21.2 \pm 5.5 b	20.9 \pm 5.8 b	$F_{3,314} = 12.3^{****}$
Shrub density at 2 m ht (no. squares uncovered)	15.4 \pm 10.3 a	19.3 \pm 7.5 b	21.2 \pm 5.6 b	21.6 \pm 5.5 b	$F_{3,314} = 11.5^{****}$
Bare ground %	4.7 \pm 11.4 c	13.0 \pm 23.2 b	20.0 \pm 22.5 a	9.5 \pm 15.1 b	$F_{3,314} = 9.5^{****}$
Herb cover %	22.0 \pm 21.8 bc	24.9 \pm 20.4 c	0.9 \pm 3.6 a	17.7 \pm 19.2 b	$F_{3,314} = 29.0^{****}$
Leaf cover %	72.8 \pm 23.1 b	62.3 \pm 25.1 a	79.2 \pm 23.4 b	71.3 \pm 26.3 b	$F_{3,314} = 6.3^{***}$

** $P < 0.01$; *** $P < 0.001$; **** $P < 0.0001$.

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