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Structure of avian communities in a mosaic of built-up and semi-natural urbanised habitats in Katima Mulilo town, Namibia

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Abstract

A simplified mapping method has been employed to quantify avian assemblages in a plot with a mosaic of built-up areas (129 ha) and semi-natural or open areas (85 ha; grass, trees, shrubs) in the Katima Mulilo town, Namibia. Overall, 65 breeding bird species were recorded in the study plots (51 in the built-up areas, and 50 in the 'open' areas). Five of them, Rock Dove *Columba livia*, Grey-headed Sparrow (*Passer diffuses*), Dark-capped Bulbul (*Pycnonotus tricolor*), Laughing Dove (*Streptopelia senegalensis*) and Blue Waxbill (*Uraeginthus angolensis*) were classified as dominants. The cumulative dominance was 69.9% in the built-up area and 55.6 % in the 'open' area. The structure of the avian community in the built-up area was unexpectedly similar to that in the 'open' area. Almost the same number of breeding species was recorded, and almost identical diversity and evenness indices were calculated. However, the Sorensen Similarity Index was rather low (I = 0.69). Also, the overall density of all breeding birds was much lower in 'open' than in the built-up area. Granivorous birds were by far the most numerous feeding guild comprising in the built-up area 68.1% and in 'open' area 62.2 % of all breeding birds. Also, similar between the two areas compared was the proportion of granivores (17.7% vs. 19.7%) and insectivores (11.5% vs. 13.2%). These were also similar to the proportions of the main nesting guilds. Only the guild nesting in/on buildings was much higher in built-up than in the 'open' area. Although species richness was not high, population densities of some species were very high in the urbanised habitat. It is recommended to protect the larger specimens of marulas and other tree species in this habitat, as they play a vital role in maintaining the high population densities.

Keywords: Urban ecology, community ecology, population densities.

1. Introduction

Throughout the world, some bird species are known to be well-adopted to live close to a man in urbanised habitats, where they may benefit from abundant food resources provided by the man (e.g. grain and its products), abundant nesting sites (e.g. tall buildings), specific microclimate (e.g. higher humidity) and low natural predation pressure (Chace & Walsh, 2006; Dunn & Weston, 2008; Magle et al., 2012; Luniak, 2017; Kopij, 2018c). In southern African countries, *Streptopelia* doves (Columbidae), *Passer* sparrows (Passeridae) and other granivore species are especially well-adopted to live in such environment, but many others appear to avoid urbanized habitats (Kopij, 1997; 2000; 2001a; 2001b; 2004; 2006; 2009; 2011; 2014; 2015; 2016; 2018a; 2018b; Hockey et al., 2005). Urbanisation mechanisms which lead to this adaptation are poorly

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understood, as urban ecology is still badly neglected as a research topic in Africa (Dunn & Weston, 2008; Magle et al., 2012; Luniak, 2017).

In Namibia, birds have been studied hitherto in two towns only: Katima Mulilo (Kopij, 2016), and Swakopmund (Kopij, 2018a). The first-mentioned town is especially interesting for urban ornithology. It is situated in the valley of a large river in the very centre of southern African subcontinent. Valleys of large tropical rivers are characterised with a high level of biodiversity (Seymour & Simmons, 2008). Not surprisingly; therefore, the town Katima Mulilo is known to have rich bird fauna, with many species which do not occur in other towns of Namibia, such as the Trumpeter Hornbill (*Bycanistes bucinator*), Schalow's Turaco (*Tauraco schalowi*), Broad-billed Roller (*Eurysomys glaucurus*), Wood Owl (*Strix woodfordii*), Tropical Boubou (*Laniarius major*), Grey-headed Bushshrike (*Malacontus blanchoti*), Terrestrial Bulbul (*Phyllastrephus terrestris*), Collared Sunbird (*Hedydipna collaris*), or Thick-billed Weaver (*Amblyospiza albifrons*) (Kopij, 2018a). Katima Mulilo town may, therefore, constitute an excellent study area to examine animal adaptations to the highly rich but man-modified environment.

A town may often comprise a mosaic of built-up ('close') and semi-natural ('open') areas of woodlands, savanna, grasslands and others. Although such 'open' areas represent more natural habitat than 'close' densely built-up areas, the 'close' habitats have sometimes higher density of shrubs and trees (though mainly of exotic origin) than the semi-natural ones.

The purpose of this study was to compare avian communities associated with a 'close' (i.e. densely built-up residential area), and semi-natural 'open area' (grassy vegetation with scattered trees and some residential areas interlaced with these open spaces), comprising a mosaic of habitats in the town of Katima Mulilo (Fig. 1). This comparison will allow assessing the role of 'open' semi-natural spaces in the cities and towns in the protection of birds and other components of biodiversity.

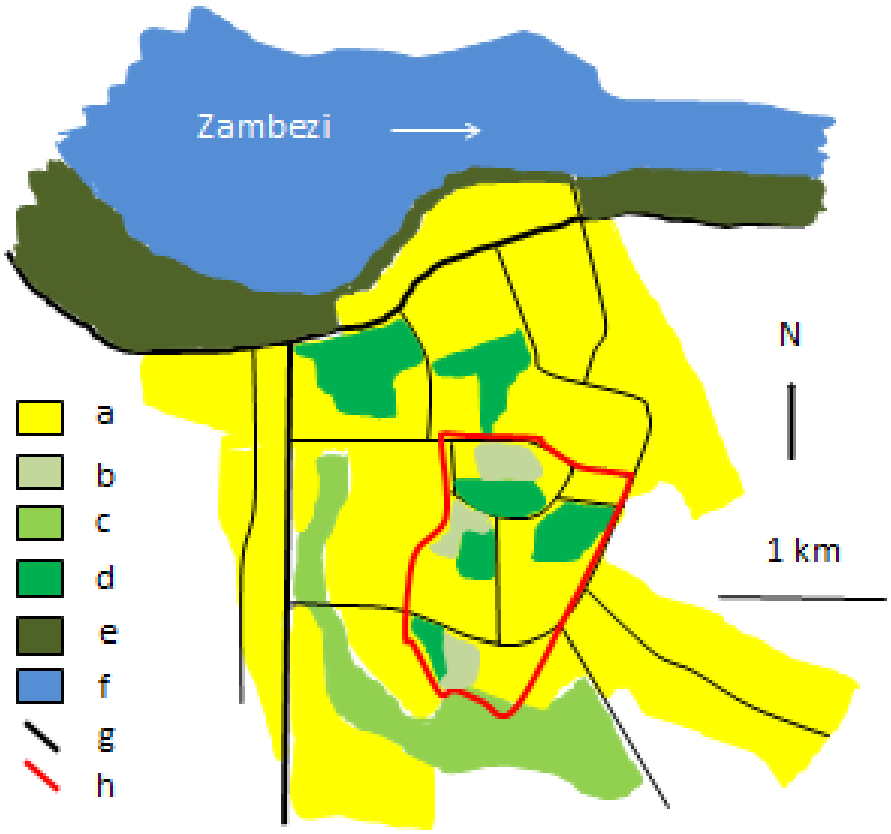

Figure 1. Location of the study plot in Katima Mulilo town. Explanation: **a.** built-up areas, **b.** grassy areas, **c.** open wetlands, **d.** remnant of Acacia savanna, **e.** riparian forest, **f.** Zambezi River, **g.** roads, and **h.** study plot.

2. Study area

The study was conducted in the town Katima Mulilo, Zambezi Region, Namibia (Fig. 1). The town is located on the right bank of the Zambezi River. The natural vegetation, which is now highly modified by human, comprises the Zambezi Riparian Forest (Mendelsohn et al., 2009). The surface of the study plot was 214 ha, built-up areas ('close') covered 129 ha, not built-up ('open') areas—85 ha. The built-up areas within the study plot comprised mainly residential flat houses. Most buildings are small one-storied houses with zinc-corrugated flat roofs, surrounded by a small yard with trees (mainly fruit trees such as mango, lemon, cassava and papaya) and some vegetables in small gardens. The semi-natural areas are covered with grass, shrubs and trees. Indigenous wild trees include among many others: Camel-thorn (*Acacia erioloba*), False Mopane (*Guibourtia coleospermum*), Jackal Berry (*Diospyros sp.*), Mopane (*Colophospermum mopane*), Silver Cluster-leaf (*Terminalia sericea*), Sycamore Fig (*Ficus sycomorus*). The most common exotic trees are gums (*Eucalyptus spp.*), jacarandas (*Jackaranda sp.*), and she oaks (*Cassuarina spp*). Some of them also grow around some buildings. The annual temperature for Katima Mulilo is 21 °C. The average maximum temperature during the hottest month (September) is 35 °C; the average minimum temperature during the coldest month (July) is 3 °C. In the most humid month (February) the humidity is 80–90%, and only 10–20% in the least humid month (September). The average annual rainfall is approximately 700 mm, the highest in Namibia. Median annual rainfall is 550–600 mm. Most of the rains fall between November and March (Mendelsohn et al., 2009). The monthly rainfall in Katima Mulilo in 2014 and 2015 is shown in Fig. 2.

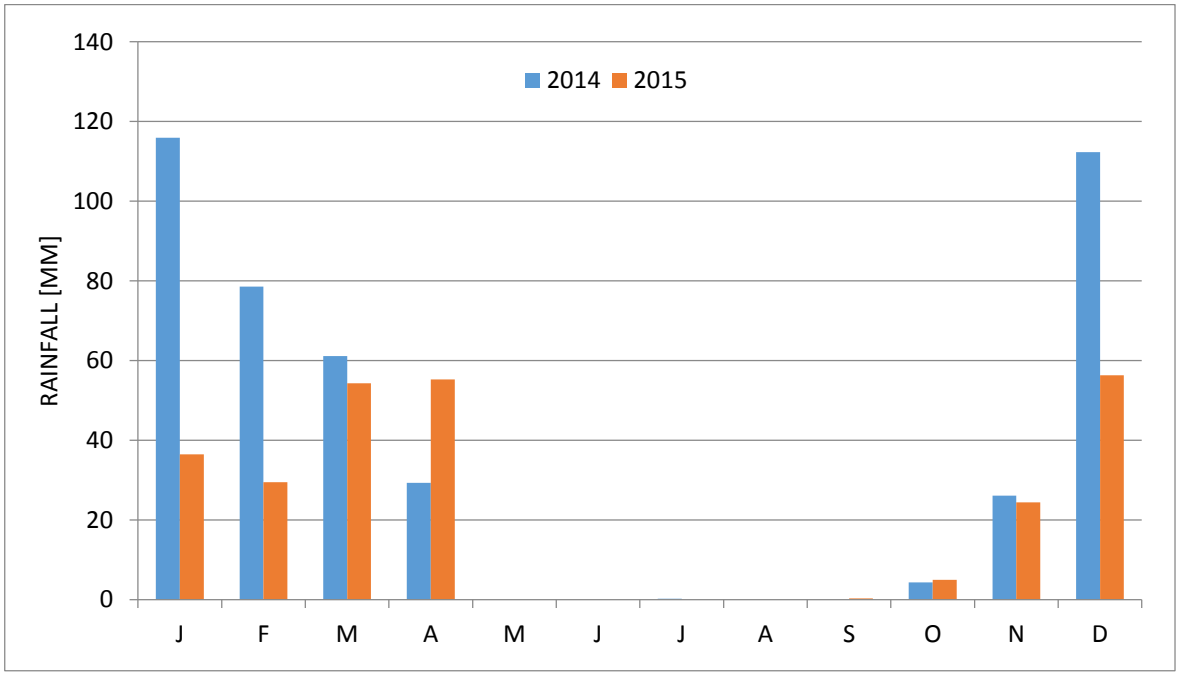

Figure 2. Monthly rainfall in 2014 and 2015 in Katima Mulilo. Source of data: https://en.climate-data.org/africa/namibia/katima-mulilo/katima-mulilo-32346/)

2. Materials and Methods

A simplified mapping method has been employed (Bibby, Burgess, & Hill, 1992; Sutherland, 1996). Each plot was surveyed twice in the dry season (June 2014) and twice in the wet season (February–March 2015). Birds were counted along all streets. Counts were conducted in the mornings under calm and cloudless weather. Each bird seen or heard was plotted on a map using symbols and abbreviation. At least two records of an individual showing territorial or breeding behaviour at the same site were interpreted as an occupied

territory, which in most cases was equal to the number of pairs. In the case of Red-billed Wood-Hoopoe (*Phoeniculus purpureus*) or Arrow-marked Babbler (*Turdoides jardineii*), it is was equal to a breeding unit consisting of breeding pair and all the helpers of this pair (co-operatively breeding species), while in the case of polygynous species the number of females were taken to estimate population density. The number of breeding pairs of the Rock Dove (*Columba livia*) was estimated by counting all individuals roosting on roofs, and dividing their number by 2.

The dominance is expressed as the percentage of the total number of pairs of a given species in relation to the total number of all pairs of all species recorded. A dominant species is defined as that comprising 5% and more of all individuals of all species recorded, while subdominant – that comprising 2–4.99%.

The following guilds were distinguished:

A. Diet: G – granivorous, I – insectivorous, F – frugivorous, N – nectarivorous, V – vegetarian, C – carnivorous.
B. Nesting: TS – in trees or shrubs, H – in holes, B – in/on buildings, V – herbaceous vegetation.

The following indices were used to characterise the diversity and evenness of the communities:

1) Shannon's diversity index: $H' = -\sum p_i \ln p_i$

where: p_i is the proportion of breeding pairs belonging to the *i*th species

2) Simpson's diversity index: $D = ((\sum n(n-1))/N(N-1)$

where: n – total number of breeding pairs belonging to a given species, N – total number of breeding pairs of all species

3) Pielou's evenness index: $J' = (-\sum p_i \ln p_i)/\ln S$

where p_i is the proportion of breeding pairs belonging to the *i*th species; S – total number of species. J' varies between 0 and 1. The less variation between species in a community, the higher J' is.

4) Community dominance index: $DI = (n_1 + n_2)/N$

where n_1, n_2 – number of pairs of two most abundant species, N – total number of pairs of all species.

5) Sörensen's Coefficient: $I = 2C/A+B$

where A – the number of bird species in one plot, B – the number of bird species in another plot, C – the number of bird species common to both plots.

Systematics and nomenclature of bird species follow Hockey et al. (2005).

Table 1. Characterisation of breeding bird community in 'close' built-up (A) and 'open' semi-natural (B) areas in Katima Mulilo, north-east Namibia.

Parameter	A	B
Number of species and pairs		
Number of species	51	50
Number of breeding pairs	397.5	376
Overall population density (pairs/100 ha)	308.1	442
Dominance		
Number of dominant species	5	4
Cumulative dominance (%)	69.9	55.6
Community dominance (DI)	0.32	0.33
Indices		
Shannon's Diversity Index (H')	2.76	3.00
Simpson's Diversity Index (D)	0.89	0.91
Pielou's Evenness Index (J')	0.70	0.77

3. Results and discussion

Overall, 65 breeding bird species were recorded in the study plots (51 in the built-up areas, and 50 in the 'open' area) (Appendix. 1), constituting 55% of all bird species recorded as breeding resident in this town (Kopij, 2016). Five of them, Rock Dove, Grey-headed Sparrow (*Passer diffusus*), Dark-capped Bulbul (*Pycnonotus tricolor*), Laughing Dove (*Streptopelia senegalensis*) and Blue Waxbill (*Uraeginthus angolensis*) were classified as dominant species, de facto eudominat, as the contributions of each of them were higher than 10%. The cumulative dominance was 69.9% in the built-up and 55.6% in the 'open' area (Table 1). Five species in 'open' area were classified as subdominants: Rock Dove, Mourning Dove *Streptopelia decipiens*, Red-billed Buffalo-Weaver (*Bubalornis niger*), Southern Masked Weaver (*Ploceus velatus*) and Cape Turtle-dove (*Streptopelia capicola*). They comprised together 15.2% of all breeding pairs. In the built-up area, there were only three subdominant species: African Palm Swift (*Cypsiurus parvus*), Fork-tailed Drongo (*Dicrurus adsimilis*) and Mourning Dove. Together they comprised 10% of all breeding pairs (Table 1).

As in most other cities in Africa and other continents (Dun & Weston, 2008; Luniak, 2017), doves and sparrows comprised the most numerous group of birds. In both areas, all four *Streptopelia*-doves were recorded. They also comprised similar proportions in each area (22% in the built-up and 22.5% of all breeding pairs in the 'open' area). Also, the proportion among them was similar in both areas compared; in the built-up area the proportion *S. senegalensis : S. decipiens : S. capicola : S. semitorquata* was as 0.71 : 0.20 : 0.03 : 0.06 (n = 87); in the 'open area' it was as 0.71 : 0.14 : 0.11 : 0.04 (n = 85). The strong dominance of *S. senegalensis* is characteristic for most, if not all, towns in Namibia (Kopij, 2014; 2018a), but it is interesting to note that the Mourning Dove was a subdominant species in both areas, situation not recorded in any town/city studied hitherto in southern Africa (Kopij, 2000; 2001a; 2001b; 2006; 2009; 2011; 2014; 2015; 2016; 2018a; 2018b).

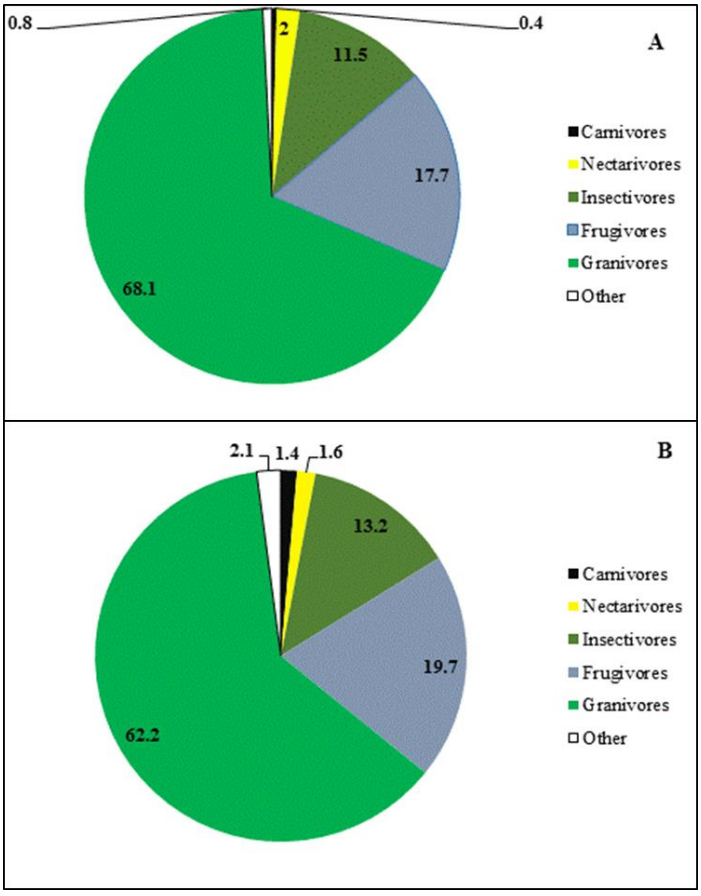

Figure 3. Feeding guilds: A: 'close' built-up areas, B: 'open' semi-natural areas.

As far as sparrows are concerned Katima Mulilo is rather untypical town in southern Africa (Kopij, 2000; 2001a; 2001b; 2006; 2009; 2011; 2014; 2015; 2018b). Only one *Passer*-species was recorded in both areas, although in both plots it was eudominant. In all other southern African cities studied so far, at least two sparrow species are common.

In general, the structure of the avian community in the built-up area was unexpectedly similar to that in the 'open' area. Almost the same number of breeding species was recorded, and almost identical diversity and evenness indices were calculated for them (Table 1). However, the Sorensen Similarity Index was rather low (I = 0.69). Also, the overall density of all breeding birds was much lower in the 'open' than in the built-up area and so was different population densities of particular species (Appendix 1).

Overall, granivorous birds were by far the most numerous feeding guild comprising in a built-up area 68.1% and in 'open' area 62.2 % of all breeding birds (Fig. 3). Such a situation is characteristic of urban habitats (Chace & Walsh, 2006). Also similar between the two areas compared was the proportion of granivores (17.7% vs. 19.7%) and insectivores (11.5% vs. 13.2%). The contribution of other feeding guilds was much lower (altogether 3.2% vs. 5.1%). However, the number of granivorous species was much lower (15 and 12 in built-up and 'open' area, respectively) than that of insectivorous species (21 vs. 20). The number of frugivorous species was similar in both plots (10 vs. 12).

Proportions of the main nesting guilds were also similar. Only the guild nesting in /on buildings was much higher in built-up than in the 'open' area as was expected (Fig. 4). In both plots, no ground-nesting species were recorded, indicating that there is a heavy predation pressure by dogs and cats or human disturbance on the ground.

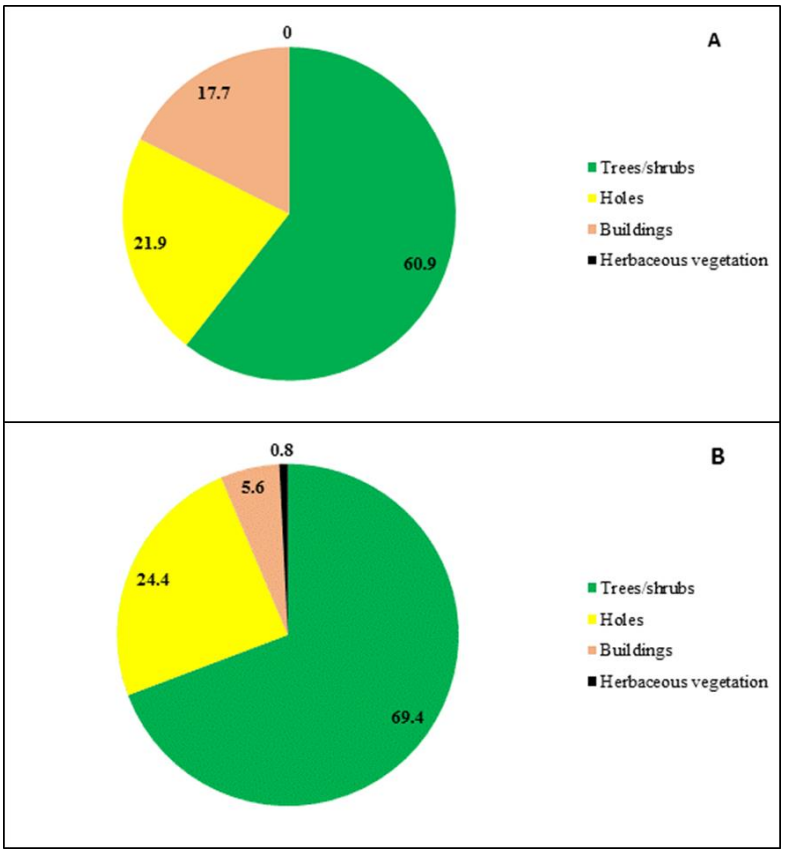

Figure 4. Nesting guilds: A: 'close' built-up areas, B: 'open' semi-natural areas.

The avian communities of built-up and 'open' areas are similar, and both are relatively rich in species. However, some species (Red-billed Buffalo Weaver, Southern Masked Weaver, Pied Crow, Grey Lorie, White-browed Robin-chat and Cape Turtle-Dove) tend to nest in much higher densities in 'open' semi-natural

than in 'close' built-up areas. It is probably because the densities of indigenous tree and shrub are higher in 'open' areas, and the level of predation and human disturbance may also be lower than in 'open' than built-up areas.

This study also shows that semi-natural areas left among densely built-up areas may play an essential role in the protection of some species in urbanised habitats. By retaining such semi-natural, 'open' areas in the town high biodiversity level can be retained.

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Appendix 1. Breeding bird assemblage in built-up areas (A: 129 ha) and semi-natural areas (B: 85 ha) in Katima Mulilo town. Dominant and subdominant species indicated with the bold case.

Species	Guilds		Number of pairs			Density (pairs/100 ha)			Dominance (%)		
	Feed	Nest	A	B	A+B	A	B	A+B	A	B	A+B
Accipiter badius	R	T	0	1	1	0.0	1.2	0.5	0.0	0.3	0.1
Accipiter tachiro	R	T	0	1	1	0.0	1.2	0.5	0.0	0.3	0.1
Amadina erythrocephala	G	T	1	0	1	0.8	0.0	0.5	0.3	0.0	0.1
Bubalornis niger	G	T	2	11	13	1.6	12.9	6.1	0.5	**2.9**	1.7
Campethera abingoni	I	H	0.5	0	0.5	0.4	0.0	0.2	0.1	0.0	0.1
Centropus superciliosus	I	T	0.5	0	0.5	0.4	0.0	0.2	0.1	0.0	0.1
Chalcomitra senegalensis	N	T	2	0	2	1.6	0.0	0.9	0.5	0.0	0.3
Chlorocichla flaviventris	F	T	0.5	0	0.5	0.4	0.0	0.2	0.1	0.0	0.1
Chlorophoneus sulfureopectus	F	T	1	2	3	0.8	2.4	1.4	0.3	0.5	0.4
Cinnyricinclus leucogaster	F	H	0	1	1	0.0	1.2	0.5	0.0	0.3	0.1
Cinnyris mariquensis	N	T	4.5	6	10.5	3.5	7.1	4.9	1.1	1.6	1.4
Cinnyris talatala	N	T	1	0	1	0.8	0.0	0.5	0.3	0.0	0.1
Cisticola chiniana	I	V	0	1	1	0.0	1.2	0.5	0.0	0.3	0.1
Clamator jacobinus	I	T	0	1	1	0.0	1.2	0.5	0.0	0.3	0.1
Columba livia	G	B	63	15	78	48.8	17.6	36.4	**15.8**	**4.0**	**10.1**
Coracias caudatus	I	H	2.5	3	5.5	1.9	3.5	2.6	0.6	0.8	0.7
Corvus albus	O	T	3	8	11	2.3	9.4	5.1	0.8	2.1	1.4
Corythaixoides concolor	F	T	1.5	4.5	6	1.2	5.3	2.8	0.4	1.2	0.8
Cossypha heuglini	I	T	2.5	6	8.5	1.9	7.1	4.0	0.6	1.6	1.1
Cypsiurus parvus	I	T	8	4	12	6.2	4.7	5.6	**2.0**	1.1	1.6
Dicrurus adsimilis	I	T	10	5	15	7.8	5.9	7.0	**2.5**	1.3	1.9
Dryoscopus cubla	I	T	1	2.5	3.5	0.8	2.9	1.6	0.3	0.7	0.5
Glaucidium perlatum	I	H	1	1	2	0.8	1.2	0.9	0.3	0.3	0.3
Halcyon leucocephala	I	H	0	0.5	0.5	0.0	0.6	0.2	0.0	0.1	0.1
Halcyon senegalensis	I	H	1	1	2	0.8	1.2	0.9	0.3	0.3	0.3
Hedydipna collaris	N	T	0.5	0	0.5	0.4	0.0	0.2	0.1	0.0	0.1
Hirundo smithii	I	B	6	5	11	4.7	5.9	5.1	1.5	1.3	1.4
Indicator indicator	I	B	0.5	0	0.5	0.4	0.0	0.2	0.1	0.0	0.1
Lagonosticta senegala	G	T	0	1	1	0.0	1.2	0.5	0.0	0.3	0.1
Lamprotonis australis	F	H	6	7	13	4.7	8.2	6.1	1.5	1.9	1.7
Lamprotornis nitens	F	H	5.5	6	11.5	4.3	7.1	5.4	1.4	1.6	1.5
Laniarius bicolor	I	T	0.5	3	3.5	0.4	3.5	1.6	0.1	0.8	0.5
Laniarius major	I	T	0.5	0	0.5	0.4	0.0	0.2	0.1	0.0	0.1
Lonchura cucculata	G	T	1	0	1	0.8	0.0	0.5	0.3	0.0	0.1
Malacontus blanchoti	I	T	0	1	1	0.0	1.2	0.5	0.0	0.3	0.1
Lybius torquatus	F	H	2	2	4	1.6	2.4	1.9	0.5	0.5	0.5
Merops pusilus	I	H	0.5	1	1.5	0.4	1.2	0.7	0.1	0.3	0.2
Micronisus gabar	R	T	0	1	1	0.0	1.2	0.5	0.0	0.3	0.1
Milvus aegyptius	R	T	1.5	2	3.5	1.2	2.4	1.6	0.4	0.5	0.5
Motacilla aguimp	I	B	1	1	2	0.8	1.2	0.9	0.3	0.3	0.3
Nilaus afer	I	T	1	0	1	0.8	0.0	0.5	0.3	0.0	0.1
Oena capensis	G	T	1	0	1	0.8	0.0	0.5	0.3	0.0	0.1
Passer diffusus	G	H	64	63	127	49.6	74.1	59.3	**16.1**	**16.8**	**16.4**
Phyllastrefus terrestris	F	T	0	2	2	0.0	2.4	0.9	0.0	0.5	0.3
Phoeniculus purpureus	I	H	1	2	3	0.8	2.4	1.4	0.3	0.5	0.4
Ploceus velatus	G	T	3	10	13	2.3	11.8	6.1	0.8	**2.7**	1.7
Ploceus xanthopterus	G	T	1	1	2	0.8	1.2	0.9	0.3	0.3	0.3
Poicephalus meyeri	F	H	2.5	2	4.5	1.9	2.4	2.1	0.6	0.5	0.6
Prinia subflava	I	V	0	2	2	0.0	2.4	0.9	0.0	0.5	0.3
Pycnonotis tricolor	F	T	47	40	87	36.4	47.1	40.7	**11.8**	**10.6**	**11.2**
Rhinopomastus cyanomelas	I	H	0.5	0	0.5	0.4	0.0	0.2	0.1	0.0	0.1
Streptopelia capicola	G	T	3	9	12	2.3	10.6	5.6	0.8	**2.4**	1.6
Streptopelia decipiens	G	T	17	12	29	13.2	14.1	13.6	**4.3**	**3.2**	**3.7**
Streptopelia semitorquata	G	T	5	3.5	8.5	3.9	4.1	4.0	1.3	0.9	1.1
Streptopelia senegalensis	G	T	62	60	122	48.1	70.6	57.0	**15.6**	**16.0**	**15.8**
Sylvietta rufescens	I	T	0	3	3	0.0	3.5	1.4	0.0	0.8	0.4
Tauraco schalowi	F	T	1	1	2	0.8	1.2	0.9	0.3	0.3	0.3
Terpsiphone viridis	I	T	6	3	9	4.7	3.5	4.2	1.5	0.8	1.2
Tockus nasutus	F	H	0	2	2	0.0	2.4	0.9	0.0	0.5	0.3
Trachyphonus vaillantii	F	H	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
Turdoides jardineii	I	T	1	3	4	0.8	3.5	1.9	0.3	0.8	0.5
Turtur afer	G	T	0.5	2	2.5	0.4	2.4	1.2	0.1	0.5	0.3
Uraeginthus angolensis	G	T	42	46	88	32.6	54.1	41.1	**10.6**	**12.2**	**11.4**
Urocolius indicus	F	T	3	5	8	2.3	5.9	3.7	0.8	1.3	1.0
Vidua chalybeata	G	T	4	0	4	3.1	0.0	1.9	1.0	0.0	0.5