Vestnik Zoologii, **53**(2): 155–164, 2019
DOI: 10.2478/vzoo-2019-0016

UDC 598.2:57.018.5(688.5)

POPULATION DENSITIES AND COMMUNITY STRUCTURE OF BIRDS BREEDING IN A SUBURBAN WOODED GRASSLAND IN THE HIGHVELD OF LESOTHO

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Population Densities and Community Structure of Birds Breeding in a Suburban Wooded Grassland in the Highveld of Lesotho. Kopij, G. — The mapping method was employed to study avian community structure in relation to rainfall in a town suburb in Highveld grassland in southern Africa. Studies were conducted in two breeding seasons: 1998, with dry spring; and 2001, with close to average spring rainfall. The total rainfall in 1998 was 1254 mm, while in 2001 it was 1445 mm, in both years much above the long-term annual average (866 mm). The avian community remained remarkably similar in both years, both in respect to the number of species (44 in 1998 and 53 in 2001), and dominance relationships. The Simpson's Diversity Index was high and also very similar in 1998 and 2001 (D = 0.91; 0.93 respectively). In all years, dominant species included the Laughing Dove, Grey-headed Sparrow, Speckled Dove, Cape Turtle-Dove and Common Fiscal. The Southern Red Bishop in 2001 was also in the group of dominants. Significant differences were noted in the overall density of all birds, but contrary to expectation density was higher in 1998, with lower rainfall, than in 2001, with higher rainfall. The proportions of nesting and feeding guilds were similar in both years compared, except for the granivores, which were proportionally more common in 1998 than in 2001. This difference was mainly due to the Laughing Dove and Grey-headed Sparrow. Generally, it appears that the suburban avian community is more stable and more diverse than neighbouring communities in the natural habitats.
Key words: feeding guilds, bird assemblages, population densities, urban ecology.

Introduction

In Europe, studies on the structure of selected communities, especially avian communities, form a substantial body of literature in community ecology. Such studies provide vital information on interspecies relationships, ecological balance, ecosystem functioning and dynamics. They are also of crucial importance for nature conservationists and environmental planners. In the Afrotropical region, quantitative studies on assemblages are, however, scanty and usually refer to ungulate assemblages. Such studies on avian communities and their year-to-year changes are limited to a few sites only (Dean, Milton, 2001; Shorrocks, 2007; Kopij 2017). Skead (1946, 1947) also studied year-to-year changes in avian assemblages, but his study plot (1 ha) was too small to draw any conclusions on species diversity, population densities or dominance structure. A few other studies (Monadjem, 2002, 2005; Parker, 2014) refer actually to seasonal (month-to-month), not year-to-year, changes in avian assemblages.

Avian communities are shaped by a number of factors, such as vegetation type, habitat fragmentation, climate variability, prevailing weather conditions, human impact, or relationship with other organisms (e. g. predation, competition). In tropical and subtropical regions of the world, avian communities appear to be more stable than in temperate regions. This is especially evident in forests and savannah biomes (Kopij, 2006, 2013 a, b, 2017; Tomiałojć, 2011; Dombrowski, 2014; Grochowski, Szlama, 2014). However, in those tropical regions of the world which experience marked seasonality in rainfall avian communities, both within the years and between years, may change in regard to species composition, dominance structure, as well as population densities of particular species (Earle, 1981; Dean, Milton, 2001; Monadjem, 2002, 2005; Kopij, 2013 a, b; Parker, 2014).

In this paper, I test a hypothesis that an increase in the amount of rainfall and its timing cause a parallel increase in the number of breeding bird species and their population densities in one of the regions of southern Africa with marked precipitation seasonality. It can be expected that an increased amount of rainfall affects positively the primary production, causing in turn the increase in food basis for consumers.

Study area

The National University of Lesotho (NUL) campus, covering an area of 82 ha, was designed as the main study site. The campus is situated at Roma, 32 km E of Maseru, Lesotho, southern Africa (29°28´ S; 27°44´ E); at the altitude of 1–650 m a. s. l. The town Roma which includes a few settlements (i. e.: the NUL campus, Thoteng, Mafekeng and Mafefoana), is nestled against foothills of the Maloti in a wide valley surrounded by sandstone cliffs. The major settlement in the valley, Roma, was founded in 1863 and in 1945 the university was established. Later two Catholic seminaries, two high schools and a hospital were also founded. Around these modern buildings, there is a striking rural setting, and cultivated fields further afield with the maize as the dominant crop. About 30 villages are situated around the sandstone cliffs.

Although the NUL campus began as open grassland, at present it represents a kind of urbanised parkland. There are 210 buildings of various size and height, tarred roads with a total length of c. 7 km, 12 oxidation dams varying in size from 10 to 100 ac, cultivated field of c. 2 ha and a multitude of small gardens with vegetables, peaches and plums. The whole area of the campus is also well endowed with various exotic trees, such as gum trees, *Eucalyptus* spp. (mostly *E. camaldulensis*), cedars, *Cedrus atlantica*, pines, *Pinus* spp. (mostly *P. radiata*), oaks, *Quercus* spp. (mostly *Q. robur*), poplars, *Populus* spp. (mainly *P. nigra 'italica'* and *P. deltoides*), acacias, *Accacia* spp. (mainly *A. dealbata),* peaches, *Prunus persica*, she-oaks, *Casuarina equiaetifolia*, false cypresses, *Chamaecyparis* spp., cypresses, *Cupressus* spp., weeping willows, *Salix babylonica,* Persian lilacs, *Melia azedarach,* sweet chestnuts, *Castanea sativa* and others (Kopij, 2001 a, b). There are also clumps and hedgerows of cotoneasters, *Cotoneaster* spp. and yellow fire-thorns, *Pyracantha angustifolia* in several sites (Kopij, 2004 a).

Lesotho climate has four distinct seasons, namely summer (November–January) characterised by high temperature and precipitation; winter (May–July) characterised by the lack of precipitation, warm temperature during the day and sudden drop after sunset; autumn (February–April) and spring (August–October) as transient periods between summer and winter (fig. 1). Weather typical of summer or winter can occur in these two seasons. 75 % of precipitation occurs between October and March (Ambrose et al., 2000). At Roma, the annual rainfall was 1445 mm in 2001, 1254 mm in 1998. In both years it was, therefore, much higher than the

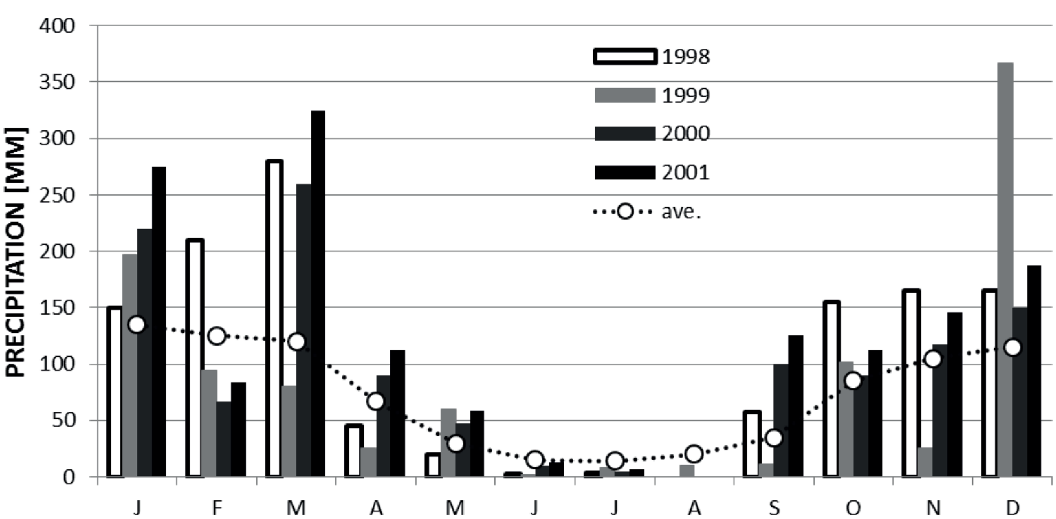

Fig. 1. Monthly rainfall at Roma during the years 1998-2001 with the long-term average.
(Data on the rainfall at Roma were obtained from D. Ambrose).

long term average annual precipitation (866 mm). In 1998, spring (August–October) rainfall at Roma was lower than in 2001 (267 mm) (fig. 1).

Methods

Studies were carried out from September to December in 1998 and in 2001. The territory mapping method (cf. Bibby et al., 1992) was employed to assess density of all potentially breeding species. Eight counts were conducted over the whole study area in each spring/summer season. Each count lasted about four hours and was conducted on two consecutive mornings.

The number of the Speckled Pigeon *Columba guinea* pairs was estimated using a modified territory mapping method (cf. Kopij, 1994). For the European Starling, *Sturnus vulgaris*, Red-winged Starling, *Onychognathus morio*, Greater Striped Swallow, *Hirundo cucculata*, Rock Martin, *Hirundo fuligula*, House Sparrow, *Passer domesticus* and Cape Sparrow, *Passer melanurus* both the mapping and the absolute (counting of occupied nests) methods were employed.

The index of bird community similarity between years was calculated using the Sörensen's Quotient of Similarity:

$$S = 2z/[x+y],$$

where z — the number of species common for the two habitats compared, x — the number of species in the habitat x, y — the number of species in the habitat y). The 'S' value changes from 0 (complete lack of similarity) to 1 (identical habitats).

Simpson's Diversity Index (D) was used to compare diversity of avian assemblages:

$$D = 1 - \sum(n/N)^2,$$

where: n — total number of pairs of particular bird species; N — total number of pairs of all bird species; no diversity if D = 0; infinite diversity if D = 1.

Differences in the densities of particular species in various seasons were tested with x^2-test. The number of resident pairs recorded was taken into account for this testing.

English and Latin names of bird species are taken from Hockey et al. (2005) and are listed in table 1.

Results

A total of 55 bird species was recorded, including five probable breeding species (table 1, appendix 1). The number was slightly higher in 2001 than in 1998 (table 2). The difference was, however, not statistically significant (chi-square test: $x^2 = 0.8$; df = 1; $p > 0.05$).

The breeding bird assemblage was similar in the two years compared. The Sørensen's Quotient of Similarity was S = 0.87. The Simpson's Diversity Index was high and very similar in 1998 and 2001 (D = 0.91; 0.93 respectively).

The overall population density of all bird species pooled was higher in 1998 than in 2001 breeding seasons ($x^2 = 5.9$ $p < 0.05$, df = 1). Out of 16 species for which the expected values were at least five (appropriate for x^2-testing), only the population densities of the Laughing Dove ($x^2 = 10.3$; $p > 0.01$; df = 1) and Grey-headed Sparrow, *Passer griseus* ($x^2 = 7.1$; $p > 0.05$; df = 1) differed significantly annually (fig. 3). For most other species, the numbers of breeding pairs were too low for statistical testing. However, marked differences were

Table 1. Changes in dominance structure in the avian assemblage during the years 1998–2001

Group	Parameter	1998	2001	x^2 - test
Dominants	Number of pairs	301	246	5.5*
	Dominance	60.2 %	57.7 %	
	Number of species	5	6	0.1
Subdominants	Number of pairs	136	103	4.6*
	Dominance	28.6 %	26.8 %	
	Number of species	9	8	0.1
Rest	Number of pairs	51	58	0.5
	Dominance	11.2 %	15.5 %	
	Number of species	30	39	1.2
All	Number of pairs	500	426	5.9*
	Number of species	44	53	0.8

recorded for the Southern Masked Weaver, *Ploceus velatus*, Speckled Pigeon and Common Fiscal, *Lanius collaris* (fig. 3).

In these two seasons compared, the group of dominant species (at least 5 % of all breeding pairs) included the Laughing Dove, Grey-headed Sparrow, Speckled Pigeon, Cape Turtle-Dove, *Streptopelia capicola* and Common Fiscal. In 2001, the Southern Red Bishop,

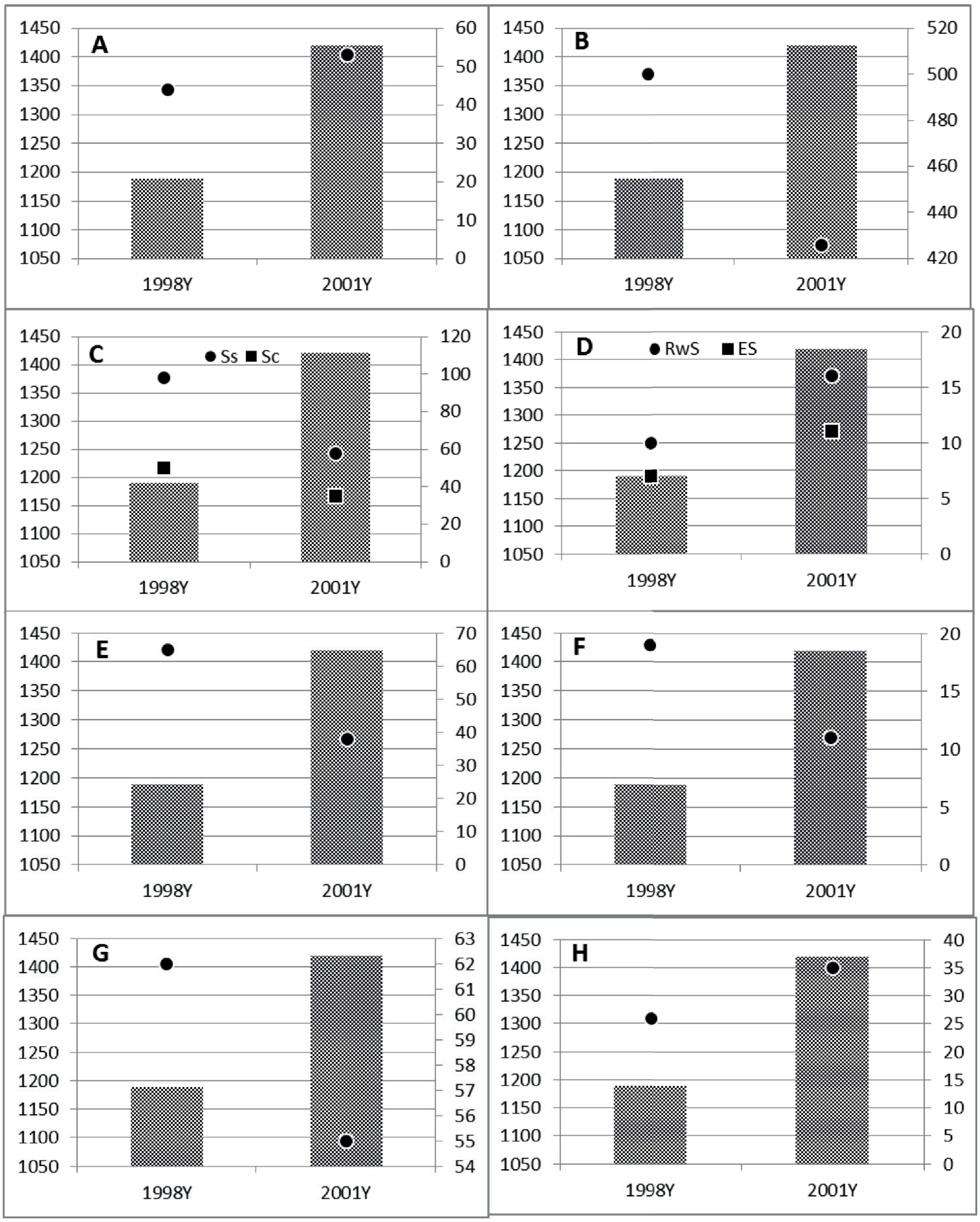

Fig. 2. Numbers (right axis; dot or square signs) of species (A), all breeding pairs (B), and breeding pairs of selected bird species (C: Ss — *Streptopelia senegalensis*, Sc — *Streptopelia capicola*; D: RwS — *Onychognathus morio*, ES — *Sturnus vulgaris*; E — *Passer griseus*; F — *Ploceus velatus*; G — *Columba guinea*, H — *Lanius collaris*) in relation to the rainfall (columns; in mm per annum; left axis).

Euplectes orix was also in this group (table 1). The group of dominants comprised 60.2 %, and 57.7 % of all breeding pairs respectively. The group of subdominants (2.0–4.9 % of all breeding pairs) included seven species, viz. the Red-eyed Bulbul, *Pycnonotus nigicans*, Red-eyed Dove, *Streptopelia semtorquata*, Red-winged Starling, Masked Weaver, Streaky-headed Seedeater, *Crithagra gularis* and Speckled Mousebird, *Colius striatus* (table 1). Twenty-eight other species (50.9 %) were represented by 1–2 pairs only (table 1). The number of breeding pairs in the dominant and subdominant group differed significantly between the two season compared (table 1).

The granivorous group was the most numerous feeding guild, accounting for 72.2 % of all breeding birds in 1998 and 64.0 % in 2001. The insectivorous group made up 9.9 % and 13.7 % respectively, frugivores 15.8 % and 19.2 %. Birds belonging to other feeding guilds (nectarivorous, piscivorous, carnivorous, omnivorous) comprised only 2.0 % and 3.1 % respectively. However, only the difference in granivores was statistically significant ($x^2 = 12.7$, df = 1, $P < 0.01$).

The proportion of particular nesting groups in 1998 and 2001 was even more similar in the study area than the proportion of feeding guilds (fig. 3). Most birds recorded as breeding on the campus nested on trees or shrubs (59.8 % in 1998 and 56.4 % in 2001), fewer on buildings (31.3 % and 29.9 % respectively), and only a small proportion on herbaceous vegetation, in holes and other sites (fig. 3).

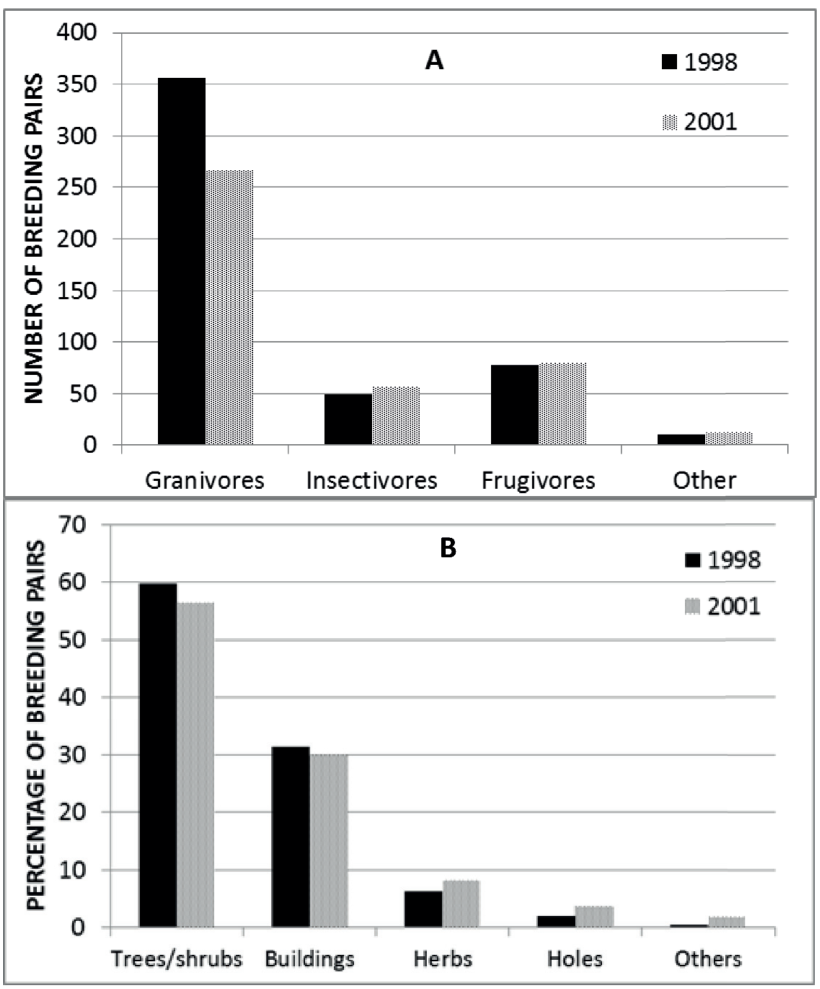

Fig. 3. Comparison of main feeding (A) and nesting (B) guilds in avian community in 1998 and 2001.

Appendix 1. Breeding bird assemblage in a suburban wooded grassland in the foothills of the Drakensberg / Malotimountains during 1998–2001. Dominant species are in bold case

Species	Number of pairs		Density (p/10 ha)		Dominance	
	1998	2001	1998	2001	1998	2001
Laughing Dove, *Streptopelia senegalensis*	**98**	**58**	**12.0**	**7.1**	**19.6**	**13.6**
Speckled Pigeon, *Columba guinea*	**62**	**55**	**7.6**	**6.7**	**12.4**	**12.9**
Grey-headed Sparrow, *Passer griseus*	**65**	**38**	**7.9**	**4.6**	**13.0**	**8.9**
Cape Turtle-Dove, *Streptopelia capicola*	**50**	**35**	**6.1**	**4.3**	**10.0**	**8.2**
Common Fiscal, *Lanius collaris*	**26**	**35**	**3.2**	**4.3**	**5.2**	**8.2**
Cape White-eye, *Zosterops pallidus*	24	20	2.9	2.4	4.8	4.7
Southern Red Bishop, *Euplectes orix*	20	**25**	2.4	3.0	4.0	**5.9**
Red-eyed Bulbul, *Pycnonotus nigricans*	22	15	2.7	1.8	4.4	3.5
Red-eyed Dove, *Streptopelia semitorquata*	19	17	2.3	2.1	3.8	4.0
Red-winged Starling, *Onychognathus morio*	10	16	1.2	2.0	2.0	3.8
Masked Weaver, *Ploceus velatus*	19	11	2.3	1.3	3.8	2.6
Streaky-headed Seedeater, *Serinus gularis*	12	15	1.5	1.8	2.4	3.5
Speckled Mousebird, *Colius striatus*	10	9	1.2	1.1	2.0	2.1
European Starling, *Sturnus vulgaris*	7	11	0.9	1.3	1.4	2.6
Greater Striped Swallow, *Hirundo cucculata*	6	7	0.7	0.9	1.2	1.6
Rock Martin, *Hirundo fuligula*	6	7	0.7	0.9	1.2	1.6
Cape Sparrow, *Passer melanurus*	4	5	0.5	0.6	0.8	1.2
Cape Robin-Chat, *Cossypha caffra*	2	5	0.2	0.6	0.4	1.2
Common Moorhen, *Gallinula chloropus*	3	3	0.4	0.4	0.6	0.7
Neddicky, *Cisticola ruficapilla*	3	1.5	0.4	0.2	0.6	0.4
Hammerkop, *Scopus umbretta*	2	3	0.2	0.4	0.4	0.7
Crested Barbet, *Trachyphonus vaillantii*	2	3	0.2	0.4	0.4	0.7
House Sparrow, *Passer domesticus*	3	3	0.4	0.4	0.6	0.7
African Hoopoe, *Upupa africana*	3.5	1	0.4	0.1	0.7	0.2
Black-throated, Canary *Serinus atrogularis*	3	1.5	0.4	0.2	0.6	0.4
Cape Weaver, *Ploceus capensis*	1	3	0.1	0.4	0.2	0.7
Little Grebe, *Tachybaptus ruficollis*	1	1	0.1	0.1	0.2	0.2
Cape Wagtail, *Motacilla capensis*	1	1	0.1	0.1	0.2	0.2
Olive Thrush, *Turdus olivaceus*	1	1	0.1	0.1	0.2	0.2
Swainson's Francolin, *Francolinus swainsonii*	0	2	0.0	0.2	0.0	0.5
Drakensberg Prinia, *Prinia hypoxantha*	2	0.5	0.2	0.1	0.4	0.1
Hadeda Ibis, *Bostrychia hagedash*	1	1	0.1	0.1	0.2	0.2
Red-throated Wryneck, *Jynx ruficollis*	1	1	0.1	0.1	0.2	0.2
Barn Owl, *Tyto alba*	1	1	0.1	0.1	0.2	0.2
Black-shouldered Kite, *Elanus caeruleus*	1	1	0.1	0.1	0.2	0.2
Purple Heron, *Ardea purpurea*	1?	1?	0.1	0.1	0.2	0.2
Black-crowned Night Heron, *Nycticorax nycticorax*	1?	1	0.1	0.1	0.2	0.2
Blacksmith Lapwing, *Vanellus armatus*	1	1	0.1	0.1	0.2	0.2
Three-banded Plover, *Charadrius tricollaris*	1?	1?	0.1	0.1	0.2	0.2
Bokmakierie, *Telophorus zeylonus*	1?	0	0.1	0.0	0.2	0.0
Levaillant's Cisticola, *Cisticola tinniens*	1	0.5	0.1	0.1	0.2	0.1
African Reed-Warbler, *Acrocephalus baeticatus*	0	1	0.0	0.1	0.0	0.2
Jacobin Cuckoo, *Clamator jacobinus*	0.5	1	0.1	0.1	0.1	0.2

Diederick Cuckoo, *Chrysococyx caprius*	0.5	0.5	0.1	0.1	0.1	0.1
Cape Reed Warbler, *Acrocephalus gracilirostris*	1	0	0.1	0.0	0.2	0.0
Rufous-chested Sparrowhawk, *Accipiter rufiventris*	0.5	0.5	0.1	0.1	0.1	0.1
Burchell's Cucal, *Centropus burchelli.*	0	1	0.0	0.1	0.0	0.2
Red-knobbed Coot, *Fulica cristata*	0	1	0.0	0.1	0.0	0.2
Red-chested Cuckoo, *Cuculus solitarius*	0	0.5	0.0	0.1	0.0	0.1
Greater Honeyguide, *Indicator indicator*	0	0.5	0.0	0.1	0.0	0.1
Egyptian Goose, *Alopochen aegyptiacus*	0	1	0.0	0.1	0.0	0.2
Cape Canary, *Serinus canicollis*	0	0.5	0.0	0.1	0.0	0.1
Cinnamon-breasted Bunting, *Emberiza tahapisi*	0	0.5	0.0	0.1	0.0	0.1
Indian Myna, *Acridotheres tristis*	0	0.5?	0.0	0.1	0.0	0.1
Black Goshawk, *Accipiter melanoleucos*	0	0.5	0.0	0.1	0.0	0.1
Total	500	426	61.0	52.0	100.0	100.0

Discussion

Rainfall is one of the most important abiotic factors influencing variations in the structure of avian communities in most Afrotropical biomes (Maclean, 1990; O'Connor et al., 2001; Sharrocks, 2007). Savannah occupies two thirds of the land surface of this zoogeographical region, and is characterised by well-pronounced seasonality of rainfall (Maclean 1990, Shorrocks, 2007). There are two climatic seasons in Lesotho: wet (September–March) and dry (April–August). Most bird species breed in the wet season, as their main food, insects and other arthropods, are then most abundant. However, some raptors, granivorous, and frugivorous birds prefer dry season for breeding, as they feed on food, which is most abundant or/and most easily available in dry season (Maclean, 1990; Hockey et al., 2005).

The increase in the amount of rainfall during the wet season in the savannah biome causes a parallel increase in the primary production (O'Connor et al., 2001; Sharrocks, 2007), and this, in turn, causes an increase in the food basis for all level-consumers, including top predators. One may, therefore, expect that in any avian communities, most species should breed in a higher density in years with high amount of rain (in a given breeding season, or in the year proceeding the breeding season), than in years with low rainfall, but other factors (e. g. vegetation growth independent of direct rainfall) may also play a role (Dean, Milton 2001; Friedl, Dean 2002). Also the dominance structure should be affected by differential rainfall, as some species should be less common (e. g. frugivores, nectarivores) and others more (e. g. insectivores, granivores) affected by the amount of rainfall.

In this study, there was no correlation between the precipitation and the number of bird species breeding in the community. Also species diversity was much the same in both years compared. As expected, significant differences were noted in the overall density of all birds. However, contrary to expectation, the density was higher in 1998, with slightly lower rainfall, than in 2001, with slightly higher rainfall. On the other hand, the number of breeding pairs in the group of dominants and subdominants was statistically different in both years compared, but their contribution to the whole community remained strikingly similar in both years compared. Other factors (e. g. the growth of some plants, seed availability), independent of spring/summer rainfall of the current breeding season may affect population densities of some bird species (Earle, 1981; Dean, Milton, 2001; Friedl, Dean, 2002).

The proportions of nesting and feeding guilds were similar in both years compared, except for the granivores, which were proportionally more abundant in 1998 (lower rainfall) compared to 2001 (higher rainfall). This was mainly due to the Laughing Dove and Grey-headed Sparrow. Although both species were in the group of dominants in both years, their population densities were significantly higher in 1998 than in 2001 (fig. 2, appendix 1). Densities of other dominant species were also higher in 1998 than in 2001, but the differences were not statistically significant (fig. 2, appendix 1). Especially interesting is the Cape Turtle-dove in this group, which nested only in slightly higher density in 1998. Unlike the Laughing Dove, the Cape Turtle-dove breeds usually in higher densities in natural savannahs than in urbanized habitats located within this biome (Kopij, 1997, 2000, 2001 c, 2006, 2013 a, b, 2015, 2016). The Cape Turtle-dove is also known to occupy territories permanently for many years (Hockey et al., 2005), and this high site tenacity could explain the stability of its numbers over the years recorded in this study. It is also important to add that although 2–3 *Streptopelia* doves often dominate in avian communities in African savannah and urbanized habitats (cf. Kopij, 2000, 2001 a, b, 2006, 2013 a, 2015, 2016), overlap in their seed food is almost complete (Maclean, 1990; Kopij, 2006), so it appears that there is not much competition for food among them, as seeds are often superabundant.

It is widely known that in years with higher rainfall seed production in savannah is much higher than in the years with low rainfall (O'Connor et al., 2001; Sharrocks, 2007), although factors other than rainfall may also play a role in this regard. However, in southern African savannah, seeds, especially grass seeds, mature in the end of the wet season, becoming freely available for birds in the dry season (Kopij, 2006). Doves begin to breed there in the middle of dry season (August) and continue in the whole wet season (Hockey et al., 2005). The population density of doves may, therefore, be not so much influenced by the actual rainfall when they breed, as it may be more influenced but the amount of the rainfall in the proceeding wet season. In the study area, the rainfall in January–April 1998 was much higher (690 mm) that in January–May 2000 (410 mm), causing higher seed production in the following dry (May–August) and wet seasons (September–December) in the same years.

There was also no correlation between feeding guilds and the differential amount of rainfall. For examples, species to large extent frugivorous, such as the Red-winged Starling, and European Starling (fig. 2), nested in higher densities in 2001 than in 1998, but the reverse was true for the Cape White-eye and Red-eyed Bulbul. The insectivorous Common Fiscal and African Hoopoe were more common in 2001 (fig. 2), but for most other insectivorous species there were no correlation between the rainfall and the number of breeding pairs. Insect abundance may not be the only factor involved here.

As shown in fig. 3, the proportion of insectivorous and frugivorous birds in a given year was similar in this study area. This is rather unusual, as in all natural habitats investigated in the Highveld the insectivorous group was much more numerous than the frugivorous guild (Kopij, 2004 a, 2006, 2013 a). Such unusual proportion in the main feeding guilds recorded can be linked to an unusual abundance of fruit trees in this study area. The much higher proportion of granivores than insectivores is, on the other hand, typical for highly modified urban habitats, where seeds, grains and their human-processed products are usually super abundant. The high proportion of granivorous birds in urban habitats is usually caused by a strong dominance of a few dove and sparrow species. In this study: the Laughing Dove, Cape Turtle-dove, Speckled Pigeon and Grey-headed Sparrow (together 55 % in 1998 and 43.6 % in 2001).

In general, it appears that avian communities in urbanized, well-timbered habitats located amidst savannah and grassland biomes, are more stable and more diverse that communities in the neighbouring natural habitats (cf. Kopij, 2001, 2004 a, 2015, 2016; Parker, 2014). This may be due to less fluctuating environmental factors in urbanized habitats, where gardens and agriculture as well as food provided by people (waste or deliberate feeding) may be adequate for many bird species throughout the year, irrespective of the amount of rainfall.

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Received 10 July 2018
Accepted 5 March 2019