diversity

MDPI

Article

Bird Species Diversity and Community Structure Across Southern African Grassland Types

Grzegorz Kopij

Department of Vertebrate Ecology, Wrocław University of Environmental & Life Sciences, ul. Kożuchowska 5b, 51-631 Wroclaw, Poland; grzegorz.kopij@upwr.edu.pl

Abstract

Grasslands occupy 24% of the Earth's surface. In most areas of the world these are either destroyed, fragmented or converted into cultivated fields. In Africa, their biodiversity is still insufficiently known. This study reports on the avian assemblages associated with grasslands in South African Highveld and Lesotho Drakensberg. Special attention was paid to the species richness, diversity, and population densities and dominance of particular species. Birds were counted by means of the Line Transect Method in three distinguished grassland types: Dry *Cymbopogon-Themeda* Grassland (transect length: 28 km), Wet *Cymbopogo-Themeda* Grassland (27 km) km, and Mountain *Themeda-Festuca* Grassland (31 km). In total, 86 bird species were recorded. While cumulative dominance was similar between the Dry and Wet Grassland (61–65%), these two were much different from that in the Mountain Grassland (46%). However the dominance index was similar in all three grassland types compared (0.25–0.33). Only one species, the long-tailed widow *Euplectes orix* was a common dominant species for all three grassland types. African stonechat, wing-snapping cisticola *Cisticola ayresii*, Levaillant's cisticola *Cisticola tinniens* and yellow bishop *Euplectes capensis* were dominant only in the Mountain Grassland; northern black korhaan *Afrotis afroides* and the eastern clapper lark *Mirafra fasciolata*—only in the Dry and Wet Grassland; ostrich *Struthio camelus*, cloud cisticola *Cisticola textrix*, African quailfinch *Ortygozpiza atricollis* and pied starling *Spreo bicolor*—only in the Dry Grassland, while the helmeted guineafowl *Numida meleagris*, zitting cisticola *Cisticola juncidis* and African pipit *Anthus cinnamomeus*—only in the Wet Grassland. Despite these obvious differences in dominance and population densities of species, Diversity and evenness indices were similar in all three grassland types. Shannon's Diversity Index (H′) varied between 1.22 and 1.35; Simpson Diversity Index between 0.91 and 0.94, while Pielou's Evenness Index (J′) varied between 0.33 and 0.36. However, Sørensen Similarity Index between the three grassland types was low, ranging between 0.07 and 0.26. Proportions of ecological guilds were similar in the Dry and Wet Grassland but differed from mountain Grassland. In comparison with other tropical grassland, avian communities in southern Africa are characterized by higher species richness and higher its variance between particular grassland types.

Keywords: grasslands; highveld; Drakensberg; community ecology; habitat conservation; population densities

Check for updates

Academic Editor: Dimitar Dimitrov

Received: 30 September 2025
Revised: 9 December 2025
Accepted: 18 December 2025
Published: 23 December 2025

Copyright: © 2025 by the author. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license.

1. Introduction

Grasslands are the largest of the four major vegetational formations on Earth and comprise 24% of its surface [1]. These occupy regions with precipitation ranging between 250 and 750 per annum, more in the mountains. The primary production of grasslands

is directly related to this precipitation and is heavily influenced by grazing by herbivore animals. Grasslands are dominated by grasses (Poaceae), while forbs and shrubs constitute an admixture.

Unfortunately due to rich soils, most grasslands have been converted to arable grounds supporting cultivation of grain (grass) plants, such as corn, wheat, and barley [2]. While in North America, most of the vast grasslands (prairie) have been almost totally converted to cultivated lands, in other parts of the world these may still present pristine state, although often overutilized as pastures for livestock [3].

Grassland ecosystems are dependent on a periodic disturbance for habitat maintenance. Grazing and fire are the major factors maintaining these ecosystems. Due to this loss (mainly to agriculture), degradation and fragmentation of grasslands occurs in most parts of the world and birds living in this biome are experiencing widespread population decline. Overall, this biome is considered as one of the terrestrial biomes most vulnerable to biodiversity loss [2–6].

Birds associated with this biome in South Africa and Lesotho were the subjects of some studies aiming to determine their status and abundance. A thorough annotated checklist of birds in Bloemfontein area, with details on the population density of some bird species has been published by Kopij (2019) [7] and further supplemented by De Swardt (2017) [8]. A similar checklist has been prepared for the northern part of the Dewetsdorp district in the south-eastern Free State province [9] and an area near Van Reenen on the Free State/KwaZulu-Natal border [10,11].

In Lesotho, data on the population densities of birds associated with grasslands were published for the Semonkong area [12], Sehlabathebe National Park [13] and Thabana Ntlenyana area in the Alpine grasslands [14]. A comparative study on the species diversity, population structure and population densities of birds was conducted in Lesotho highlands, where bird community in the Alpine grassland was compared with that in the mountain grassland [15]. So far, this is the only study dealing comprehensively on the species diversity, population structure, and population densities of birds associated with grasslands in southern Africa.

The purpose of this study was to investigate the species richness, biodiversity, and population densities of birds associated with major types of southern African grasslands. This information are of vital importance for conservation biology and may motivate the establishment of various conservation areas in the Highveld and Maloti/Drakensberg regions. Specific questions addressed in this paper are: (1) how species richness and species diversity differ among African grassland types, (2) how does density of insectivores vs. granivores differ among African grassland types, (3) do avian functional groups differ between modified vs. unaltered grassland habitats, (4) what are the similarities and difference between African grasslands and other grasslands in the world.

2. Materials and Methods

2.1. Study Area

Grasslands occupy two physiographic units in southern Africa: Highveld and Moloti/Drakensberg (Figure 1). Two subunits are recognized in the Highveld: (1) the Arid West, located at 900–1600 m asl., with an annual rainfall of 450–600 mm per annum, covered with the Dry *Cymbopogon-Themeda* grassland (DCT), and (2) Central Plateaus at altitude of 1500–2000 m with an annual rainfall of 650–900 mm, covered with the Wet *Cymbopogon-Themeda* grassland (WCT). The Moloti/Drakensberg in the east forms mountains. Being located at 1600–3459 m asl., it is covered with the Mountain *Festuca-Themeda* grassland (MFT), with annual rainfall higher than 900 mm [16] (Figure 1). The total surface area of the Highveld grasslands is 241,638 km^2, whereas the Maloti/Drakensberg

grasslands—114,784 km^2. Beyond southern Africa, the only other larger grassy area is the Ethiopian montane grasslands (221,114 km^2) [6].

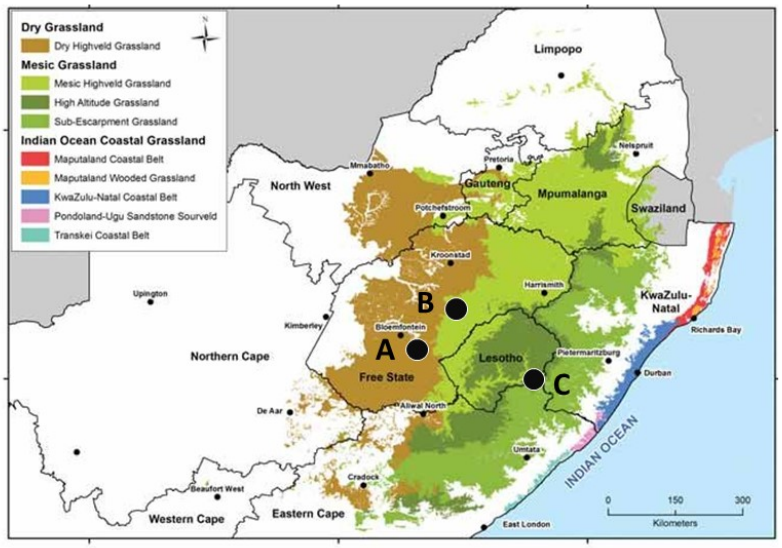


Figure 1. Distribution of three grassland types in South Africa and Lesotho (modified from [17]), with the study plots indicated with yellow dots: A—Dry *Cymbopogon-Themeda*, B—Wet *Cymbopogon-Themeda*, and C—Mountain *Festuca-Themeda*.

Studies were conducted in three sites in suothern Africa (Figure 1). Each transect was divided into a few sections:

1. DCT in the northern part of the Dewetsdorp District, Free State, South Africa (c. 1000 km^2); located c. 1500 m asl. Semiarid climate with a mean annual precipitation of 340 mm at Dewetsdorp. Dominant grass species are represented by the red grass (*Themeda triandra*) and the terpentine grass (*Cymbopogon plurinoides*) (Figure 2). The total length of transects was 28 km. Dates and time of counting: (a) 14 December 1993, 7:30–11:00 (the first section of the transect) and 19 January 1994, 7:30–10:30 (continuation of the first section of the transect); the section of this transect ran through eroded grassy plain with a sparse karroid vegetation in the upper stretch of the Modder River valley, 13 km in length; (b) 28 November 1993, 7:00–11:00 (the first part) and 12 January 1994, 7:30–11:00 (the second part), this section of the transect ran through a grassy plain with sparse *Acacia karroo* thorns in the middle stretch of the Modder River valley, 15 km in length.



Figure 2. Dry *Cympobogon-Themeda* grassland near Dewetdorp.

2. WCT in Willem Pretorius Game Reserve (12,000 ha), Free Sate, South Africa, located at c. 1440 m asl. Semiarid climate with a mean annual precipitation of 770 mm in Winburg. Dominant grass species included the red grass and the terpentine grass (Figure 3). The total length of transects was 27 km. Dates and time of counting: (a) 22 November 1995, 5:30–12:10, this section of the transect run through an undulating grassy plain, its total length was 13 km; (b) 27 November 1995, 7:00–11:00, this section of the transect ran through a grassy plain with spars thorn shrubs on a shorline of the Allamanskraal Dam, 8 km in length; (c) 27 November 1995, 11:00–15:00, this section of the transect was designed in a grassy plain transient to *Acacia karroo* thorns, with some norrow reed-beds along the Sand River, 6 km in length.



Figure 3. Wet *Cympobogon-Themeda* grassland in willem Pretorius Game Reserve.

3. MFT in Sehlabathebe National Park (7239 ha), Lesotho; 2200–2600 m a.s.l. Temperate climate with hot/wet summers and cold/dry winters; mean annual precipitation at Sehlabathebe: 769 mm. The total length of transects was 31 km. The dominant grass species were represented by the goat festuca (*Festuca caprina*), the Red Grass, mountain broom grass (*Merxmuellera macowanii*), and the weeping lovegrass (*Eragrostis curvula*) (Figure 4). Dates and time of counting: (a) 12 January 2001, 6:00–11:00, this section of the transect was designed in a grassland with numerous stream valleys at the foothill of Thaba Ntšo along the road from the research station to the lodge. Its length was 9 km; (b) 13 January 2001, 6:00–10:00, this section of the transect ran through mainly short grassland with a few stream valleys and sand-stone formation, from the research station along the north-west border of the park through Koti-se-Seholo Tsoe-likane to Tsoelikane Falls, its length was 7 km; (c) 13 January 2001, 10:00–12:30, this section of the transect was desinged in an extensive marshland with fairly tall and dense grasses and sedges along the Tsoelikane River from Letamong village to the waterfall, 6 km in length; (d) 15 January 2001, 6:00–11:00, this section of the transect ran in a grassland with sandstone formations and stream valleys, from the research station through the north-western corner of the park, Herdboy and Central Valleys to the waterfall, 9 km in length.



Figure 4. Mountain *Themeda-Festuca* grassland in Sehlabathebe National Park.

2.2. Data Collection

Studies were conducted by means of the Line Transect Method. As in most studies on birds, transects had no belts, i.e., distances between birds and observers were not measured [18,19]. All counts were conducted in the peak of breeding season of most bird species (November–January), which coincided with the middle of the rainy season in the grasslands (October–March) [16]. All counts were conducted under sunny and calm weather conditions. For count dates and time on specific transect, see Section 2.1.

As recommended in the Line Transect Method, a potential breeding pair, not an individual, was a census unit [18,19]. Counts were conducted once on each transect by walking slowly in the mornings (from 5 a.m. to c. 11 a.m.) and recording all seen and heard birds. Spatial attention was paid to singing males and individuals showing territorial or/and breeding behaviour. A caution was taken to not count the same birds twice by noting their movements and by recording simultaneously singing males (i.e., singing at the same time). All birds passing over the area were excluded and were definitively not associated with the grassland as a breeding or/and feeding habitat (e.g., herons, egrets, cormorants).

In the case of the southern masked weaver *Ploceus velatus* and southern red bishop *Euplectes orix*, the number of recorded breeding pairs was taken as being equal to the number of males counted. In the case of the helmeted guineafowl and mousebirds the number of breeding pairs was based on the number of adult birds present in the flock/group divided by 2.

2.3. Data Analysis

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. The dominant species comprised at last 5%, while the subdominant, 2–4.99% of all breeding pairs of all species.

The linear density is expressed as the number of breeding pairs per 1 km of a transect. Overall density is expressed as the linear density of all breeding pairs of all species per 1 km (≈10 ha).

The following guilds were distinguished:

Diet: G—granivorous, I—insectivorous, F—frugivorous, N—nectarivores, C—carnivorous and O—omnivorous.

Foraging: T—gleaning eaves of trees and shrubs, V—gleaning herbaceous vegetation, G—collecting from the ground, A—aerial feeders, P—perching and pursue

Nesting: T–in trees or shrubs, V—in herbaceous vegetation, R—on rocks, G—on the ground, H—in holes

In this study, guild analysis was based on the number of breeding species (not on the number of recorded species as in studies performed by numerous authors). This yields a much more accurate picture of proportions between particular guild categories. The following indices were used to characterize 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. The minimum value of H′ is 0 (it indicates no diversity, i.e., only one species was recorded), and there is no upper limit to H′. The maximum value would occur if all species had the same number of breeding pairs.

(2) Simpson's diversity index:

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

where n = the total number of breeding pairs belonging to a given species, N = the total number of breeding pairs of all species. D ranges between 0 and 1; 1 represents infinite diversity, while 0 represents no diversity.

(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 is the total number of species. J′ varies between 0 and 1. The less variation between species in a community, the higher J′.

(4) Community dominance index:

$$DI = (n_1 + n_2)/N$$

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

The Sørensen index was used to investigate similarities between avian communities in various grassland types: S = 2c/(a + b), where "c" is the number of species common for two compared communities, a = the number of species in the community "a", b = the number of species in the community "b". The index changes from 0 (absolute dissimilarity between communities) to 1 (identical communities).

The one-way analysis of variance (ANOVA) was used to identify differences in the abundance of species between various grassland types. The χ^2-test was used to test differences in the number of species recorded between various grassland types, in the number of breeding pairs per 1 km between different grassland types, and between main ecological guilds within the same grassland type.

Species nomenclature and systematics follow Clements et al. (2017) [20].

3. Results

3.1. Avian Diversity

A total of 86 species were recorded in all grassland types pooled (Table A1). The number of species was not significantly different between DCT and WCT (x^2 = 3.1,

$p > 0.05$, df = 1) and between WCT and MFT ($x^2 = 1.0$, $p > 0.01$, df = 1), but it was significantly different between DCT and MFT ($x^2 = 4.5$, $p < 0.05$, df = 1).

The number of dominant species was the highest (n = 7) in WCT, the lowest (n = 5) in MFT (Table 1). Only one species, the long-tailed widow *Euplectes progne* was a common dominant species for all three grassland types. All others, i.e., African stonechat *Saxicola torquatus*, wing-snapping cisticola *Cisticola ayresii*, Levaillant's cisticola *Cisticola tinniens* and yellow bishop *Euplectes capensis* were dominant only in MFT. The northern black korhaan *Afrotis afroides* and the eastern clapper lark *Mirafra fasciolota* were common dominant species in the DCT and WCT. The ostrich *Struthio camelus*, cloud cisticola *Cisticola textrix*, African quailfinch *Ortygospiza atricollis* and pied starling *Spreo bicolor* were the only dominant species in the DCT, while the helmeted guineafowl, zitting cisticola *Cisticola juncides* and African pipit *Anthus cinnamomeus* were the only dominant species in the WCT (Table 2).

Table 1. Characterization of bird communities in various grassland types.

Parameter	DCT	WCT	MFT	Total
Number of pairs	429	630	666	1720
Number of species	28	43	47	86
Overall density	151.4	233.3	214.8	200.0
Cumulative dominance	61.4	64.6	46.2	29.0
Dominance index	0.28	0.33	0.25	0.19
Number of dominant species	6	7	5	14
H′ index	1.22	1.27	1.35	1.59
J′ index	0.36	0.36	0.33	0.36
D index	0.92	0.91	0.94	0.96

Table 2. Dominant species (dominance values are given) in three grassland types. All species recorded as dominant at least in one grassland type are listed. A dominance higher than 5.0 is in bold case.

Scientific Name	Common Name	DCT	WCT	MFT	Total
Mirafra fasciolata	Eastern clapper lark	**7.8**	**23.5**	0	**10.5**
Euplectes progne	Long-tailed widowbird	**11.6**	**9.0**	**5.0**	**8.1**
Saxicola torquatus	African stonechat	4.2	1.3	**12.0**	**6.2**
Afrotis afroides	Northern black korhaan	**13**	**6.5**	0	**5.6**
Cisticola ayresii	Wing-snapping cisticola	0	0	**12.9**	**5.0**
Euplectes capensis	Yellow bishop	1.9	0.2	**10.7**	4.6
Spreo bicolor	Pied starling	**15.6**	0	0.2	3.9
Numida meleagris	Helmeted guineafowl	3.3	**6.7**	0	3.3
Cisticola juncides	Zitting cisticola	0	**7.3**	0	2.7
Cisticola textrix	Cloud cisticola	**7.5**	2.2	0	2.7
Struthio camelus	Common ostrich	0	**6.2**	0	2.3
Cisticola tinniens	Levaillant's cisticola	0	0.2	**5.6**	2.2
Ortygospiza atricoll	African quailfinch	**5.9**	0	1.7	2.1
Ploceus velatus	Southern masked weaver	**6.4**	1.4	0	2.1
Anthus cinnamomeus	African pipit	0	**5.4**	0	2.0
Number of pairs of all breeding species		429	630	666	1720

Large terrestrial birds, columbids and larks were more common in the DCT and WCT than in MFT, whereas the reverse was true in the case of raptors, cisticolas, turdids and fringillids (mainly canaries) (Table 3).

Table 3. Percentage contribution of selected bird groups in various grassland types.

Group	DCT	WCT	MFT	Total
NON-PASSERINES				
Columbidae (doves)	5.2	7.7	0.7	4.3
Large terrestrial birds	27.2	26.7	6.1	17.9
Raptors	0	0	2.1	1.0
Others	2.1	3.6	6.8	4.9
Sub-total	34.5	38	15.7	28.1
PASSERINES				
Alaudidae	7.8	23.5	0	10.5
Anthus/Macronyx spp.	1.4	5.4	5.2	6.1
Cisticola spp.	7.5	9.2	18.5	9.6
Euplectes spp.	13.5	10.3	16.5	13.5
Ploceidae	11.3	2.1	9.2	5.6
Turdidae	8.2	3.5	15.4	9.2
Fringillidae	0.2	0.9	16.6	4.4
Others	15.6	7.1	2.9	13.0
Sub-total	49.9	54.9	81.4	58.9
Total	84.4	92.9	97.1	86
N of pairs of all species	429	630	666	1720

While cumulative dominance was similar between the DCT and WCT (61–65%), these two were much different from that in MFT (46%). However, the dominance index was similar in all three grassland types compared (0.25–0.33) (Table 1).

3.2. Comparison of Avian Richness Between Different Grassland Types

Diversity and evenness indices were similar in all three grassland types. Shannon's Diversity Index (H′) varied insignificantly, i.e., the variance is not homogenous (ANOVA, F = 1.31, df = 87, $p > 0.05$) between 1.22 and 1.35. The Simpson Diversity Index was calculated to directly relate the values of diversity index, where value 1 is infinite diversity and 0 is a lack of any diversity. It was very high, but varied between 0.91 and 0.94, being therefore almost identical between the three grassland types compared. Pielou's Dominance Index (J′) was low (mainly due to a strong domination of a few species) and varied between 0.33 and 0.36 (Table 1) and was therefore almost identical.

The Sørensen Similarity Index between the three grassland types was low, ranging between 0.20 and 0.54 (Table 4). The differences in the number of species were statistically significant only between the DCT and MFT (Table 4). Only four species (out of 87), namely the African stonechat, Cape robin-chat *Cossypha caffra,* long-tailed widow and Cape turtle dove *Streptopelia capicola* were common for all three grassland types. Such numbers were the highest between DCT and WFT (n = 19), but much lower between DCT and MFT (n = 9) and between WCT and MFT (n = 6).

Table 4. Sørensen index (right diagonal) and statistical differences (χ^2-test) between the numbers of species (left diagonal). The asterisk (*) indicates statistically significant difference ($p < 0.01$).

	DCT	WCT	MFT
DCT	x	0.54	0.32
WCT	1.54	x	0.20
MFT	18.53 *	0.05	x

3.3. Comparison of Population Densities of Particular Bird Species in Different Grasslands

The overall differences in population densities between the three grassland types were statistically significant ($F_{2,158}$ = 0.93; $p < 0.001$; Table 5), as the variances were not homogenous.

Table 5. Results of ANOVA analysis used to identify the existence of differences in the abundance of species between various grassland types.

Source of Variation	SS	Df	S^2	F
Between	11,726.8	2	5863.4	0.93
Within	997,170.3	258	6311.2	
Total	1,008,897	260		

$F_{2,158}$ = 0.93; $p < 0.001$.

Nine species have reached a linear density higher than 10 pairs per 10 km: six species in the DCT (eastern clapper lark, cloud cisticola, long-tailed widow, northern black korhaan, and pied starling), three species in the MFT (African stonechat, wing-snapping cisticola, and yellow bishop), and only one species, the eastern clapper lark, in the WCT (however it was the only species with a density higher than 20 pairs per 10 km).

3.4. Ecological Guilds

Two main feeding guilds were distinguished in the study area: granivores and insectivores. The proportion of insectivores in the MFT was much higher than granivores, in the DCT it was equal, while in the WCT the proportion of granivores was higher than insectivores (Figure 5).

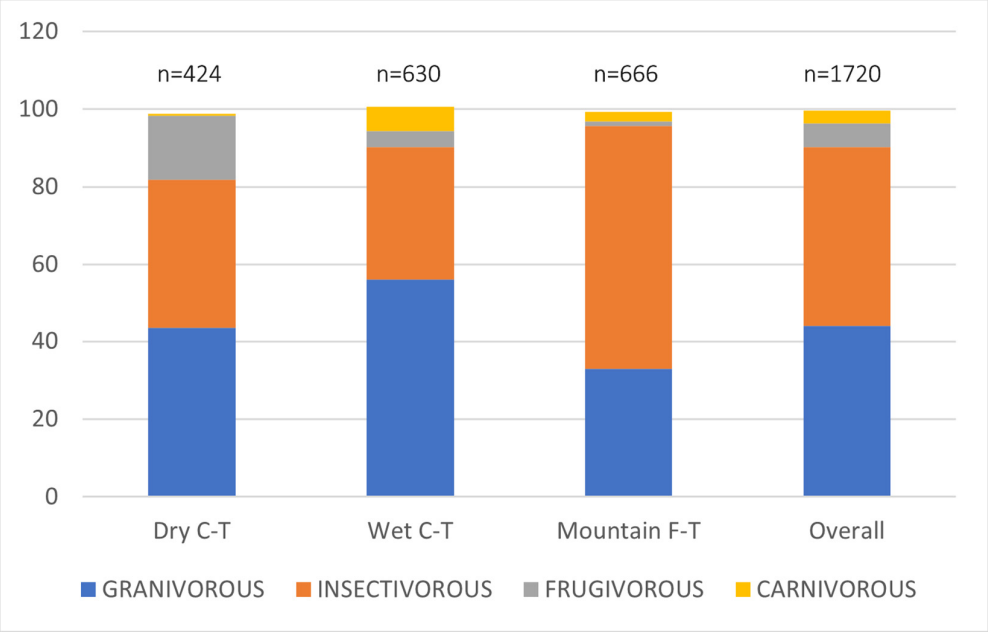


Figure 5. Proportions of main feeding guilds (based on the number of breeding pairs shown above each column) in three grassland types in southern Africa.

Among foraging guilds, more than 60% of all birds in DCT and WCT, were those foraging on the ground, but in the MFT it was only 41%. Also the proportion of birds foraging in trees and shrubs was lower in the mountain than in the other grassland types. On the other hand, the proportion of birds with hunting technique 'perch and purchase'

were higher in the MFT than DCT and WCT, while the aerial feeders were found only in the MFT (Figure 6).

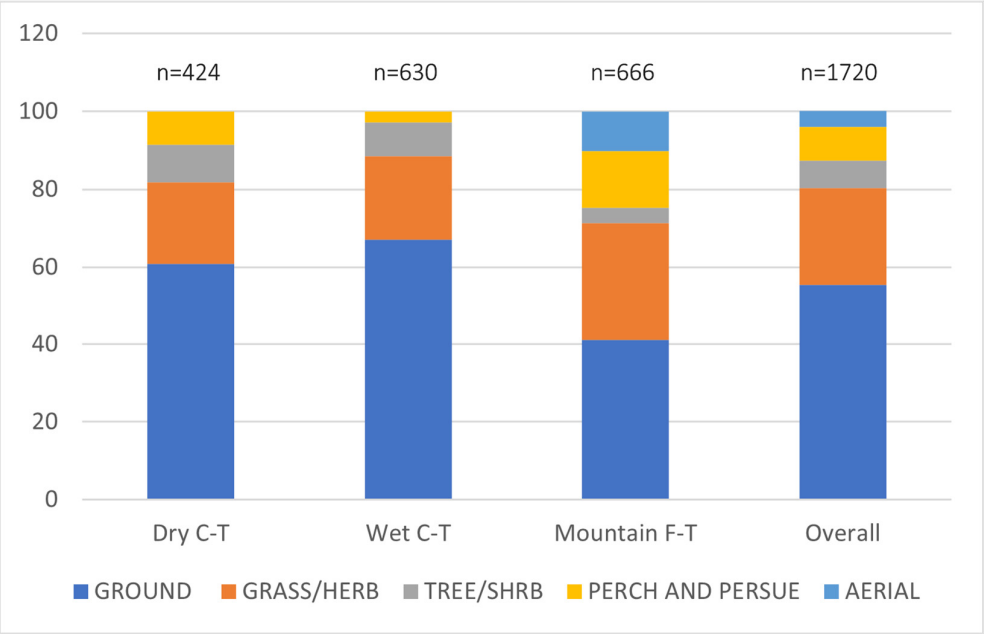


Figure 6. Proportions of main foraging guilds (based on the number of breeding pairs shown above each column) in three grassland types in southern Africa.

Proportions of birds nesting on the ground or in trees and shrubs were higher in the WCT than in other grassland types, whereas the proportions of birds nesting in grassy and herbaceous vegetation or on rocks were higher in the MFT than in the other grassland types. The proportion of hole-nesting birds were much higher in the DCT than in any other type (Figure 7, Table 6).

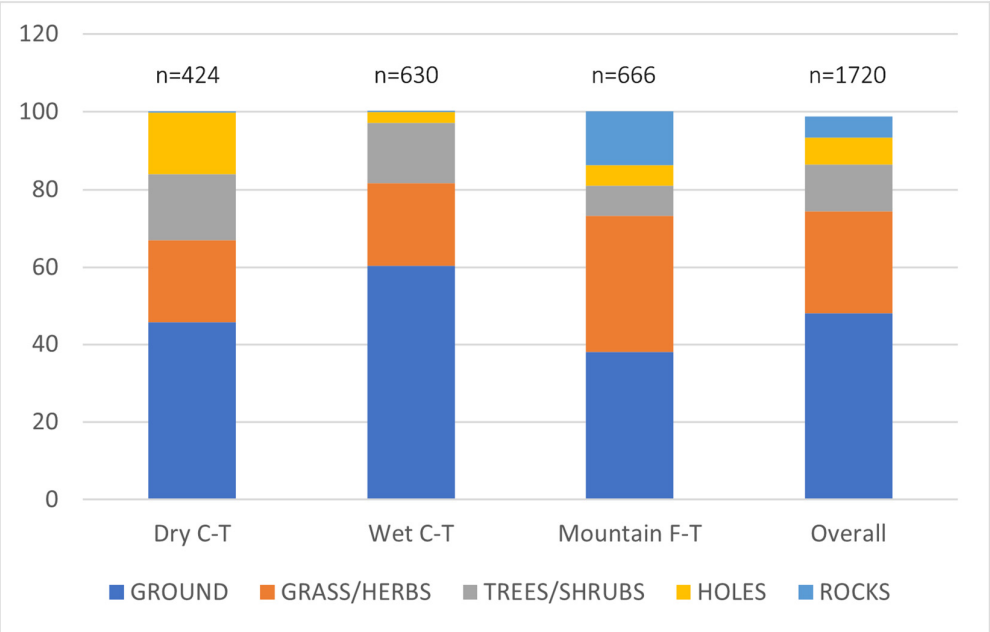


Figure 7. Proportions of main nesting guilds (based on the number of breeding pairs shown above each column) in three grassland types in southern Africa.

Table 6. Statistical differences between main ecological guilds.

Comparable Guilds	DCT	WCT	MFT	Overall
Main feeding guilds				
Granivorous (O_1)	186	353	219	757
Insectivorous (O_2)	165	214	418	796
E	175	284	319	777
χ^2	1.33	33.88	62.22	1.01
p	>0.05	<0.01	<0.01	>0.05
Granivorous (O_1)	186	353	219	757
All others (O_2)	238	278	444	958
E	212	315	332	857
χ^2	6.34	8.87	76.27	23.61
p	<0.05	<0.01	<0.01	<0.01
Main foraging guilds				
Ground (O_1)	258	423	274	955
All others (O_2)	166	207	392	767
E	212	315	333	861
χ^2	19.88	73.90	21.01	20.44
p	<0.01	<0.01	<0.01	<0.01
Main nesting guilds				
Ground (O_1)	195	381	253	829
All others (O_2)	230	251	413	871
E	213	316	333	850
χ^2	2.88	26.80	38.40	1.04
p	>0.05	<0.01	<0.01	>0.05

4. Discussion

4.1. Methodological Limitations

The applied method is suitable to calculate the dominance, but less so to assess population densities. For species that were elusive, not active vocally, or nocturnal (e.g., fiscal flycatcher *Sigelus silens*, pririt batis *Batis pririt*, long-billed crombec *Sylvietta rufescens*, red-billed firefinch *Logonosticta senegala*, owls Strigiformes, nightjars Caprimulgiformes), the population densities were certainly underestimated. To minimize such bias, studies should be supplemented by netting, point counts or even by call stimulations. On the other hand, for conspicuous, and vocally active species (larks, most cisticola species, doves, crows) estimations were much more precise and accurate.

Statistical differences in density, dominance, diversity, and species composition among habitats could be partly due to differences in the detection probability. Only single counts were conducted on each transect, but counts were conducted under similar weather conditions, with exactly the same method and always by the same researcher.

Although each grassland type was surveyed in a different year (1993, 1995, and 2001), the interannual variation grazing, and land use were minimal, not affecting results in a significant way. Also the rainfall amount was close to the long-term means in all studied years. Furthermore, the studied grasslands were situated within protected areas (except

for the DCT, which was utilized as a pasture for the livestock), so their vegetation did not change significantly to date.

While the DCT, WCT and MFT are distinguished based on the dominant plant species and general climatic context, no specific data were quantified on vegetation height, cover, or heterogeneity, grazing intensity or livestock density, fire regime, mowing, and other management practices. Differences recorded in avian communities may therefore reflect these unmeasured habitat variation as well as intrinsic differences between grassland types.

The density values are only rough estimations, which represent minimal values. These values, which are called linear densities or relative densities, are good for internal comparisons between particular species, transects and habitats. Such comparisons are especially justified if counts were conducted in same period of the year (rainy season), time of the day (mornings), with a similar speed (walking slowly) and by the same researcher, as it was in this study.

4.2. Differences in Community Structure in Relation to Environmental Factors

Several factors could influence the observed differences in community structure of three compared grassland types. The vegetation structure (short vs. long grass, sparse vs. dense grass cover; grazed vs. not grazed grass) appears to be the most important covariance of habitat [21–23]. This study revealed a fairly clear separation of the DCT, WCT, and MFT. The separation is not so clear between the DCT and WCT, although it remains unknown to what extent the bird community in DCT has been modified by livestock grazing (WCT and MFT were not grazed by the livestock). A separation of bird communities was also revealed within relatively small area in Serengeti Plains, Tanzania, along the main types of tropical grasslands, i.e., short grass, intermediate grass, long grass and wooded grass land [21].

The proportion of insectivorous to granivorous birds was much higher in MFT than in other types of southern African grasslands, while the reverse was true in WCT. Since both study plots were within protected areas, the management effect was excluded. It can be assumed that diversity and abundance of insects is higher in MFT than in WCT, and/or the seed productivity is higher in WCT than in MFT. In other words, the proportion of insectivores in avian community in grasslands may increase with the altitude. The equal proportion of granivores and insectivores recorded in DCT was rather unexpected, but it could have been distorted by management effect (grazing by the livestock), which can create conducive environment for insects. It should also be mentioned here, that small river valleys and wetlands situated within the DCT harbour large breeding colonies of the Southern Red Bishop. Although these birds do not nest in the neighbouring grassland, they may forage in large flocks on seeds in these grasslands (G. Kopij, own observation).

Higher proportion of ground nesting birds than all the other nesting guilds taken together in WCT and MFT is caused by the fact that trees, shrubs and rocks are rare or absent in these grasslands, especially in intact areas. Equal proportion of ground nesting birds and all other guilds recorded in DCT, can be linked with the presence of some shrubs or even trees in this grassland utilized as pasture for livestock.

4.3. Comparison with Other African Grasslands

The comparative analysis of the population densities and dominance values obtained in this study with similar studies on avian assemblages conducted in other grasslands in Africa is very limited. Most of these studies did not present species abundance based on the number of breeding pairs recorded, as recommended by Sutherland (1996) [18], Bibby et al. (2012) [19] and other authors. Breeding population can only be reliable assessed if the breeding pair, not an individual, is a census unit.

There is apparently one such study conducted in the Serengeti National Park, Tanzania [21], although even there, data on population densities and dominance are not presented straightforward. These are here retrieved from provided raw data (only the number of recorded breeding pairs are given). It is therefore justified to present these re-calculated data. Studies were conducted by means of the mapping method [18,19] in 10 study plots (long grass—4 plots, short grass—3, intermediate grass—1, wood grass—2), each plot was 25 ha in surface area, one was 21 ha (the surface area of all pooled plots was therefore 246 ha). A total of 576 breeding pairs, represented by 34 species were recorded. Three groups were distinguished. (1) Ubiquitous species: pectoral-patch cisticola *Cisticola brunnescens*: 6.0 p./10 ha (25.7%), zitting cisticola *Cisticola juncidis*: 5.2 p./10 ha (22.4%), rufous-naped lark *Mirafra africana* 1.0 p./10 ha (4.2%). (2) Differential species: rosy-breasted longclaw *Macronyx ameliae*: 0.6 p./10 ha (2.4%), white-tailed lark *Mirafra albicauda*: 3.8 p./10 ha (16.3%), winding cisticola *Cisticola galactotes*: 0.5 p./10 ha (2.1%), Somali short-toed lark *Calandrella somalica*: 0.6 p./10 ha (2.6%), African pipit: 0.8 p./10 ha (3.3%), red-capped lark *Calandrella cinerea*: 1.2 p./10 ha (5.0%), Fischer's sparrow-lark *Eremopterix leucopareia*: 0.6 p./10 ha (2.4%), capped wheatear *Oenanthe pileate*: 0.9 p./10 ha (4.0%). (3) Other species with at least 3 pairs: harlequin quail *Coturnix delegorguei* 0.4 p./10 ha (1.6%), croaking cisticola *Cisticola natalensis*: 0.3 p./10 ha (1.4%), coqui francolin *Francolinus coqui*: 0.1 p./10 ha (0.5%), siffling cisticola *Cisticola brachyptera*: 0.2 p./10 ha (0.9%), plain-backed pipit *Anthus leucophrys*: 0.2 p./10 ha (0.9%), crowned lapwing *Vanellus coronatus*: 0.1 p./10 ha (0.5%). Similarities between plots varied from 0.02 to 0.97. Therefore, the number of dominant species was four and these comprised as much as 69.4%; the dominance index was also high (0.48). Major taxonomic groups included: cisticolas (53.4%), larks (30.7%), pipit (6.8%), turdids (4.0%), large terrestrial birds (3.9), columbids (0.2%), no raptors, others (1.1%). Most of these values differ significantly from those obtained in this study. Especially evident is a much higher contribution of cisticolas and larks in the breeding bird community in Tanzania, if compare with southern African grasslands.

4.4. Avian Communities of Natural Compared to Modified Grasslands

Natural grasslands can be converted to artificial grasslands, to cultivated fields dominated by wheat (de facto also grasses), or to artificial parklands (forest- or savanna-type habitats). In terms of species richness, artificial temperate grasslands are pauperized in comparison with natural ones [24]. For instance, in the state of New York, USA, more than 90% of all breeding pairs belonged to the red-winged blackbird *Agelaius phoeniceus*, bobolink *Dolichonyx oryzivorus* and savanna sparrow *Passerculus sandwichensis*; while in Saskatchewan highlands, Canada, the vesper sparrow *Pooectes gramineus* strongly dominated in the avian community [25].

In southern Africa, even very transformed grasslands present a more heterogenous environment than natural ones. For instance, in the city of Bloemfontein, which is situated amidst DCT, 78 breeding species were recorded [26], so what has been recorded in the pure surrounding DCT (this study) is almost doubled. The most common were the speckled pigeon *Columba guinea*, Cape turtle dove, laughing dove *Spilopelia senegalensis*, little swift *Apus affinis*, house sparrow *Passer domesticus* and Cape sparrow *Passer melanurus*. None of these species was recorded as the dominant in the natural DCT (this study). Granivores comprised 71% of all breeding birds, frugivores—14%, while insectivores—15%; shrub/tree nesting birds—61%, while birds nesting on/in buildings—36% [20], quite different proportions from those recorded in the DCT. Farmlands around Bloemfontein also hold quite different breeding bird communities [7] from those in the natural DCT surrounding the city (this study).

In Roma suburban woodland, Lesotho, transformed from the WCT, 55 breeding species were recorded, with five dominant species, such as the laughing dove, southern grey-headed sparrow *Passer diffusus*, speckled pigeon, Cape turtle dove and common fiscal *Lanius collaris* [27]. These species were therefore totally different from those recorded as dominant in the natural DCT [9]. Granivores were by far (72%) more abundant than insectivores (10%) and frugivores (16%); while the shrub/tree nesting birds clearly dominated (60%) over those adapting buildings as nesting sites (31%). These proportions are quite different from those recorded in the surrounding WCT (this study). In farmlands of Lesotho Drakensberg, the breeding bird communities were also quite different from those recorded in natural MFT [12,13].

4.5. Comparison with Grasslands Out of Africa

4.5.1. Species Compositions and Dominant Species

Species composition of grassland birds is influenced by a set of factors that include habitat types, landscape forms and composition, and the availability of prey [28]. In grassland communities, the variation in overall species density is strongly affected by the variation in densities of the dominant species, which can change dramatically from year to year [29].

In North American prairies, plant species composition differs distinctly between seeded grassland and native mixed prairie, but the differences are not translated into meaningful differences in species composition, diversity, and population density of breeding birds. The most abundant bird species, the grasshopper sparrow *Ammodrammus savannarum*, western meadowlark *Sturnella neglecta*, eastern meadowlark *Sturnella magna*, dickcissel *Spiza americana*, and lark sparrow *Chondestes grammacus* were similarly abundant in the seeded grassland and the mixed prairie [30].

In Argentinian pampas, the species richness was not high (28 species, including 13 grassland dependent species, viz. the red-winged tinamou *Rynchotus rufescens*, Darwin's nothura *Nothura darwini*, pampas pipit *Anthus chacoensis*, correndera pipit *Anthus correndera*, grassland sparrow *Ammodramus humeralis*, grassland yellow finch *Sicalis luteola*, white-browed meadowlark *Leistes superciliaris*, long-tailed meadowlark *Sturnella loyca*; and four habitat-independent species, viz. the southern lapwing *Vanellus chilensis*, firewood-gatherer *Annumbius annumbi*, rufous-collared sparrow *Zonotrichia capensis*, suffron finch *Sicalis flaveola* [31].

In southern Brazilian campos, the species richness was relatively high (42 species, including 17 grassland dependent). The following were dominant species: the rufous-collared sparrow (15.4%), grassland sparrow (10.6%), pampa finch *Embernagra platensis* (9.5%), long-tailed reed finch *Donacospiza albifrons* (6.0%), grassland yellow finch (5.0%). These comprised together 46.5% [32].

Most of bird species in North American and Neotropical grasslands are representatives of families other than in Africa, viz. Funariidae, Icteridae, Parulidae, Passerellidae, Thraupidae and Tyrannidae. Only few families are the same (Motacillidae, Fringillidae, Turdidae).

4.5.2. Large Terrestrial Birds

In North American prairie, larger species are most abundant in relatively stable and productive tall grass and are rare in instable and less productive short grass [33], but the reverse is true in South African Highveld. Such large terrestrial species as the northern black korhaan, crowned lapwing, helmeted guineafowl, spurfowls, and francolins are abundant in instable and relatively low-productive DCT, and are rare in more stable and more productive MFT. It is partly because some of these large terrestrial species are insectivorous to a certain extent, and insects and other arthropods are more abundant in drier grasslands

(G. Kopij, own observation). The other reason may be that hunting pressure on larger species is not so high in southern Africa, as it is in temperate grasslands.

Although the MFT is characterized by more stable year-to-year climatic conditions, seasonal variation in primary productivity is much higher than in DCT, and it may adversely affect sedentary species, especially those characterized by a high level of philopatry.

4.5.3. Genera Representativeness and Level of Endemism

According to Cody (1966) [34], avian diversity and general structure are similar in Arctic, temperate, and tropical grasslands. As can be seen in Table 7, many bird species breeding in southern African grasslands have their ecomorphological equivalents in grasslands in other parts of the world. However, on the global scale, the species diversity of birds in grasslands is declining northwards. While the Arctic grasslands support 22 typical grassland bird species, in temperate North American grasslands, 35 such species have been identified [30], 121 species were recorded in Neotropical grasslands [5] and 96 species in Afrotropical grasslands (G. Kopij, own data). The likely reason for such discrepancy is a differential primary production resulting in differences in food abundance. In Arctic grassland, the mean productivity is 144 g/m^2/year, whereas in tropical grasslands it varies between 1000 and 2000 g/m^2/year [1]. This is further evidenced by the number of dominant avian genera. While the average number of species with genera is strikingly similar in the Arctic, temperate, and Afrotropical grasslands (1.4; 1.5 and 1.6, respectively), the number of dominant genera is declining from tropical to Arctic grasslands. Neotropical grasslands are dominated by 10 genera, Afrotropical by four, temperate by one, and Arctic grasslands by none genus [5], (G. Kopij own data).

Not only the diversity of grassland genera, but also endemism shows a clinal change from the tropical towards Arctic grasslands. While only 5 and 6 endemic genera occur in the Arctic and temperate grasslands, respectively, 37 and 59 such genera were identified in the Neotropical and Afrotropical grasslands, respectively. There are no endemic families in Arctic and temperate grasslands [5], but as many as 16 such families are in Afrotropical grasslands (G. Kopij, own data).

4.5.4. Spatial and Temporal Variation in Population Densities

In temperate grasslands of North America, overall breeding population density does not differ between various grassland types [33]. In southern Africa, the differences are, however, evident and may be accounted for by main differences in the primary productivity of particular habitats, as well as by the seasonal variation in this productivity. Long-term studies on overall breeding densities of birds in southern African grasslands are lacking. Year-to-year or even month-to-month variations in such densities are however apparent, especially in DCT and WCT [38–40]. In southern African grasslands, in springs (beginning of the wet season) with rainfall lower than the long-term average, some territorial bird species may vacate their territories established in dry areas and settle down in the neighbouring more humid areas (i.e., near rivers, dams, gardens, irrigated fields, urbanized habitats), which may have more food resources [38–40].

Breeding population densities of some bird species may show marked month-to-month and year-to-year fluctuations following strictly similar changes in the precipitation (e.g., [40]).

Table 7. Avian ecological equivalents in temperate and tropical grasslands. Based on: [5,21,32,35–37].

Type	Temperate Grasslands		Neotropical Grasslands		Afrotropical Grasslands		
	Prairie	**Steppe**	**Pampas**	**Campos**	**Highveld**	**Maloti**	**Serengeti**
Lapwing-type	*Bertramia chilensis*	*Vanellus vanellus*	*Vanellus chilensis*	*Vanellus chilensis*	*Vanellus coronatus*	*Vanellus armatus*	*Vanellus coronatus*
Partridge-type	-	*Perdix perdix*	*Nothura maculosa*	*Nothura maculosa*	*Francolinus levaillantoides*	*Francolinus africanus*	*Francolinus coqui*
Quail-type	*Tympanuchus* spp.	*Coturnix coturnix*	-	-	*Coturnix coturnix*	*Cotunix coturnix*	*Coturnix delegorguei*
Kestrel-type	*Falco sparverius*	*Falco naumanni*	*Falco sparverius*	*Falco sparverius*	*Falco rupicoloides*	*Falco rupicolis*	*Falco rupicoloides*
Falcon-type	*Falco mexicanus*	*Falco cherrug*	*Caracara plancus*	*Caracara plancus*	*Falco peregrinus*	*Falco biarmicus*	*Falco biarmicus*
Buzzard-type	*Buteo swainsoni*	*Buteo rufinus*	*Parabuteo unicintcus*	*Buteogallus meridionalis*	*Buteo rufofuscus*	*Buteo rufofuscus*	*Buteo augur*
Harrier-type	*Circus cyaneus*	*Circus pygargus*	*Circus buffoni*	*Circus cinereus*	*Circus ranivorus*	*Circus maura*	*Circus ranivorus*
Eagle-type	*Aquila chrysaetos*	*Aquila nipalensis*	*Buteo albicaudatus*	*Harpyhaliaetus coronatus*	*Aquila rapax*	*Aquila verrrauxi*	*Aquila rapax*
Vulture-type	*Cathares aura*	*Gyps fulvus*	*Coragyps atrata*	*Coragyps atratus*	*Gyps africanus*	*Gyps coprotheres*	*Gyps rueppellii*
Bubo-type	*Bubo virginianus*		*Bubo virginianus*	*Bubo virginianus*	*Bubo africanus*	*Bubo capensis*	*Bubo africanus*
Asio-type	*Asio otus*	*Asio otus*	*Asio otus*	*Asio flammeus*	*Asio capensis*	-	*Asio capensis*
Tyto-type	*Tyto alba*	*Tyto alba*	*Tyto alba*	*Tyto alba*	*Tyto alba*	*Tyto alba*	*Tyto alba*
Athene-type	*Athene cunicularia*	*Athene noctua*	*Athene cunicularia*	*Athene cunicularia*	-	-	-
Dove-type	*Zanaida macroura*	*Streptopelia decaocto*	*Zanaida auriculata*	*Zanaida auriculata*	*Spilopelia senegalensis*	*Streptopelia capensis*	*Spilopelia senegalensis*
Pipit-type	*Anthus spraguei*	*Anthus campestris*	*Anthus correndera*	*Anthus hellmayri*	*Anthus cinnamomeus*	*Anthus hoeschi*	*Anthus cinnamomeus*
Bunting-type	*Calamospiza melanocorys*	*Emberiza calandra*	*Sporophila caerulescens*	*Sicalis luteola*	*Emberiza tahapisi*	*Emberiza capensis*	*Emberiza leucopareia*
Cisticola-type	-	*Cisticola juncidis*	-	-	*Cisticola textrix*	*Cisticola ayresii*	*Cisticola brunnescens*
Lark-type	*Strunella neglecta*	*Alauda arvensis*	*Strunella defilippi*	*Strunella supercilliaris*	*Mirafra apiata*	*Galerida magnirostris*	*Mirafra albicauda*
Sparrow-type	*Zonotrichia leucophrys*	*Passer domesticus*	*Zonotrichia capensis*	*Zonotrichia capensis*	*Passer melanurus*	*Passer diffusus*	*Passer suahelicus*

4.6. Indicator Species in Southern African Grasslands

Maphisa et al. (2017) [11] have identified eight bird species as indicators of grassland environmental health/habitat suitability for breeding birds (well-balanced fire and grazing management to maintain proper height and cover density) in South Africa (WCT), namely the wing-snapping cisticola: 4–5 exx./10 ha, Cape longclaw: 4–5 exx./10 ha, African pipit: 3 exx./10 ha, African quail finch: 2–3 exx./10 ha, yellow-breasted pipit: 1 exx./10 ha, Red-capped Lark: 1 ex./10 ha, zitting cisticola: 0.5 ex./10 ha and common quail: 1 ex./10 ha. Of these, only the yellow-breasted pipit is a threatened species. All these species were common both in Maphisa's Ingula study plots near Ven Reenen on the border of the Free State and KwaZulu-Natal [10], as well as in study plots designed in the Free State and Lesotho (this

study). To these could be added the long-tailed widow, eastern clapper lark and mountain pipit. For most of these species, population density was related to grass height and cover. The mountain pipit, clapper lark, African quailfinch, and common quail prefer short and sparse grass. The African pipit, yellow-breasted pipit, and red-capped lark prefer short and dense grass. The long-tailed widow, Cape longclaw and zitting cisticola prefer tall and dense grass. The wing-snapping cisticola preferred grass of intermediate height and cover.

4.7. Conservation Implications

The Highveld grasslands are poorly conserved today. Less than 1% of the Highveld grasslands are under protection (e.g., Golden Gate and Qwakwa National Parks, Willem Pretorius Game Reserve), while more than 7% of the Drakensberg (e.g., Sehlabathebe National Park) grassland is protected [13]. There is an urgent need to develop a net of protected areas throughout the Highveld and Drakensberg, as these areas are seriously threatened by conversion into cultivated fields and intensively used (often overgrazed) pastures. The Maloti/Drakensberg grasslands of southern Africa with a surface area of 114,782 km^2 are regarded as "the largest and most intact grasslands remaining on Earth" [6]. The most iconic species of this area are the southern bald ibis *Geronticus calvus*, bearded vulture *Gypaetus barbatus*, Drakensberg rock jumper *Chaetops aurantius*, yellow-breasted pipit, mountain pipit, and Drakensberg siskin *Crithagra symonsi.* It still remains one of the best-preserved tropical grasslands in the world (62% are intact). About 50% of the Highveld grasslands are intact, while the Ethiopian mountain grasslands are among the least intact (<1% are intact) grasslands in the world [6].

For a few reasons, birds are good indicators of grassland condition [10,11,41]. Some bird species are strictly associated with a particular grass type (e.g., *Cisticola* cisticolas and *Mirafra* larks) [41]. Many bird species (e.g., *Ploceus* weavers, *Passer* sparrows and *Streptopelia* doves) may breed across a broad gradient of human-modified grassland, from pristine grasslands through pastures and to grasslands totally transformed into cultivated fields or urbanized habitats. Most bird species live only a few years, so changes in species composition and abundance will be reflected relatively quickly after a disturbance in grassland.

Eight species recorded in the study are included in 'The 2025 Red Data Book of Birds of South Africa, Lesotho and Eswatini' [42]; five species were in the MFT, three in the DCT and only one in the WCT grassland (Table 8). If the dominance value is taken into account, the DCT and MFT are by far much more important for the threatened bird species than the WCT, while the MFT will be twice more important than DCT (Table 8). Further studies in a wider context and deeper analysis may better elucidate the role of different grassland types in southern Africa in the protection of threatened birds species.

Table 8. Conservation status of threatened birds recorded in the grassland types. Dominance value is listed for each species (taken from Table A1).

Common Name	Scientific Name	Status	Rank	DCT	WCT	MFT
Bearded vulture	*Gypaetus barbatus*	CR	5			0.2
Blue korhaan	*Eupodotis caerulescens*	VU	3	2.1		
Ground woodpecker	*Geocolaptes olivaceus*	NT	2		0.2	2.3
Hamerkop	*Scopus umbretta*	NT	2	0.5		
Lanner falcon	*Falco biarmicus*	NT	2			0.2
Mountain pipit	*Anthus hoeschi*	NT	2			4.4
Three-banded plover	*Charadrius tricollaris*	LC	1	1.2		
Yellow-breast. pipit	*Anthus chloris*	VU	3			0.6
Total score (rank x dominance)				9.0	0.4	16.6

Grasslands are ecosystems that have evolved with frequent disturbances. Historically, the agents principally responsible for maintaining grassland habitats were drought, grazing by native herbivores, and fire. Therefore, grazing by livestock, prescribed burning, and mowing/haying are the most frequently used, as well as versatile, grassland management techniques [43]. Grassland birds prefer a wide range of grass heights and grass densities. Three species groups may be distinguished in this regard: (a) species preferring short and sparse vegetation, (b) species preferring taller and more dense vegetation, (c) species showing no preferences. Due to differences in these preferences and regional differences in soils and plant species composition, the responses of particular grass bird species to specific grassland management practices can be variable and often are regionally dependent [3,22]. As a result, grassland areas must be managed as a mosaic of different grassland types. Such situations are maintained through a rotational system which provides a variety of habitat types in every year, ensuring the availability of suitable habitat for birds [44]. The conversion of grasslands into forest plantations or urbanized areas appear to be more harmful to the taxonomic and functional diversity of birds than the conversion into pastures or agricultural land [45]. In order to halt current species habitat loss and species extinction, conservation decisions on reliable density estimates and their temporal changes are critical.

5. Conclusions

Southern African grasslands are characterized by relatively high levels of species richness and high biodiversity. It tends to increase with altitude, being the highest in the Mountain Grassland. Species compositions, dominance and population densities vary markedly between different grassland types. The avifauna of southern African grasslands requires further studies, especially related to the population density estimates and population dynamics of some indicative species.

Funding: This research received no external funding.

Data Availability Statement: The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author.

Acknowledgments: O. B. Kok, J. van Niekerk, and Therons are thanked for logical help during this study.

Conflicts of Interest: The author declares no conflicts of interest.

Appendix A

Table A1. Bird assemblages in South African grasslands. Dominant species in whatever grassland type are indicated with bold case. Guilds: Fe—feeding, Ne—nesting, Fo—foraging. For further details see the text. Parameters: n—number of breeding pairs, d—linear density (pairs per 10 km, ≈10 ha), %d—dominance. χ^2 test: value marked with an asterisk (*) indicates $p < 0.01$, value marked with '-' indicates $p < 0.05$, value not marked: $p > 0.05$. Dominant species and all dominance values of at least 5 are given in bold case.

Scientific Species Name	Common Species Name	Guilds			DCT, 28 km			WCT, 27 km			MFT, 31 km			Total			χ^2 test			
		Fe	Ne	Fo	n	d	%d	n	d	%d	n	d	%d	n	d	%d	1/2/3	1/2	1/3	2/3
Mirafra fasciolata	**Eastern clapper lark**	G	G	G	33	11.8	**7.8**	148	54.8	**23.5**	0	0	0	181	21	**10.5**	200.1 *	36.5 *	16.5 *	74.0 *
Euplectes progne	**Long-tailed widowbird**	G	V	V	49	17.5	**11.6**	57	21.1	**9**	33	10.6	**5**	139	16.2	**8.1**	6.4 -	0.3	1.6	3.2
Saxicola torquatus	**African stonechat**	I	G	P	18	6.4	4.2	8	3	1.3	80	25.8	**12**	106	12.3	**6.2**	86.1 *	1.9	19.6 *	29.5 *
Afrotis afroides	**Northern black korhaan**	I	G	G	55	19.6	**13**	41	15.2	**6.5**	0	0	0	96	11.2	**5.6**	51.1 *	1	27.5 *	20.5 *

Table A1. *Cont.*

Scientific Species Name	Common Species Name	Guilds			DCT, 28 km			WCT, 27 km			MFT, 31 km			Total			χ^2 test			
		Fe	Ne	Fo	n	d	%d	n	d	%d	n	d	%d	n	d	%d	1/2/3	1/2	1/3	2/3
Cisticola ayresii	**Wing-snapping cisticola**	I	V	G	0	0	0	0	0	0	86	27.7	**12.9**	86	10	**5**	172.0 *		43.0 *	43.0 *
Euplectes capensis	**Yellow bishop**	G	V	V	8	2.9	1.9	1	0.4	0.2	71	22.9	**10.7**	80	9.3	4.6	142.0 *		35.5 *	35.5 *
Spreo bicolor	**Pied starling**	F	H	G	66	23.6	**15.6**	0	0	0	1	0.3	0.2	67	7.8	3.9	128.1 *	33 *	31.5 *	0.5
Numida meleagris	**Helmeted guineafowl**	G	G	G	14	5	3.3	42	15.6	**6.7**	0	0	0	56	6.5	3.3	49.0 *	7 *	7.0 *	21.0 *
Cisticola juncides	**Zitting cisticola**	I	V	V	0	0	0	46	17	**7.3**	0	0	0	46	5.3	2.7	92.0 *	23 *		23.0 *
Cisticola textrix	**Cloud cisticola**	I	V	V	32	11.4	**7.5**	14	5.2	2.2	0	0	0	46	5.3	2.7	33.6 *	3.5	16.0 *	7.0 -
Struthio camelus	**Common ostrich**	O	G	G	0	0	0	39	14.4	**6.2**	0	0	0	39	4.5	2.3	78.0 *	19.5 *		19.5 *
Cisticola tinniens	**Levaillant's cisticola**	I	V	V	0	0	0	1	0.4	0.2	37	11.9	**5.6**	38	4.4	2.2	70.2 *	0.5	18.5 *	17.1 *
Ortygospiza atricollis	**African quailfinch**	G	G	G	25	8.9	**5.9**	0	0	0	11	3.5	1.7	36	4.2	2.1	26.2 *	12.5 *	2.7	5.5 -
Ploceus velatus	**Southern masked weaver**	G	T	T	27	9.6	**6.4**	9	3.3	1.4	0	0	0	36	4.2	2.1	31.5 *	4.5 -	13.5 *	4.5 -
Streptopelia capicola	Cape turtle-dove	G	T	G	13	4.6	3.1	22	8.1	3.5	1	0.3	0.2	36	4.2	2.1	18.5 *	1.2	5.1 -	9.6 *
Macronyx capensis	Cape longclaw	I	G	G	6	2.1	1.4	0	0	0	29	9.4	4.4	35	4.1	2	40.2 *	3	7.6 *	14.5 *
Anthus cinnamomeus	**African pipit**	I	G	G	0	0	0	34	12.6	**5.4**	0	0	0	34	4	2	68.0 *	17 *		17.0 *
Motacilla capensis	Cape wagtail	I	G	G	11	3.9	2.6	0	0	0	21	6.8	3.2	32	3.7	1.9	20.7 *	5.5 -	1.6	10.5 *
Crithagra symonsi	Drakensberg siskin	G	G	V	0	0	0	0	0	0	30	9.7	4.5	30	3.5	1.7	60.0 *		15.0*	15.0 *
Anthus hoeschi	Mountain pipit	I	G	G	0	0	0	0	0	0	29	9.4	4.4	29	3.4	1.7	58.0 *		14.5 *	14.5 *
Pternistes natalensis	Natal spurfowl	G	G	G	0	0	0	27	10	4.3	0	0	0	27	3.1	1.6	54.0 *	13.5 *		13.5 *
Coturnix coturnix	Common quail	I	G	G	0	0	0	0	0	0	26	8.4	3.9	26	3	1.5	52.0 *		13.0 *	13.0 *
Spilopelia senegalensis	Laughing dove	G	T	G	6	2.1	1.4	20	7.4	3.2	0	0	0	26	3	1.5	24.3 *	3.8	3	10.0 *
Apus barbatus	African black swift	I	R	A	0	0	0	0	0	0	25	8.1	3.8	25	2.9	1.5	50.0 *		12.5 *	12.5 *
Emberiza capensis	Cape bunting	G	R	G	0	0	0	0	0	0	24	7.7	3.6	24	2.8	1.4	48.0 *		12.0 *	12.0 *
Myrmecocichla formicivora	Ant-eating chat	I	G	P	14	5	3.3	9	3.3	1.4	0	0	0	23	2.7	1.3	13.1 *	0.5	7.0 *	4.5
Riparia cincta	Banded martin	I	H	A	0	0	0	0	0	0	18	5.8	2.7	18	2.1	1	36.0 *		9.0 *	9.0 *
Monticola explorator	Sentinel rock thrush	I	G	G	0	0	0	0	0	0	17	5.5	2.6	17	2	1	34.0 *		8.5 *	8.5 *
Ploceus capensis	Cape weaver	G	T	T	0	0	0	0	0	0	17	5.5	2.6	17	2	1	34.0 *		8.5 *	8.5 *
Gocolaptes olivaceus	Ground woodpecker	I	H	G	0	0	0	1	0.4	0.2	15	4.8	2.3	16	1.9	0.9	26.4 *	0.5	7.5 *	6.1 -
Serinus canicollis	Cape canary	G	T	V	0	0	0	0	0	0	15	4.8	2.3	15	1.7	0.9	30.0 *		7.5 *	7.5 *
Vanellus armatus	Blacksmith lapwing	I	G	G	0	0	0	14	5.2	2.2	0	0	0	14	1.6	0.8	28	7		7.0 *
Telophorus zeyonensis	Bokmakierie	I	T	T	5	1.8	1.2	8	3	1.3	0	0	0	13	1.5	0.8	7.5	0.3	2.5	4
Vanellus coronatus	Crowned lapwing	I	G	G	0	0	0	12	4.4	1.9	0	0	0	12	1.4	0.7	24	6 -		6.0 -
Cossypha caffra	Cape robin-chat	F	T	T	3	1.1	0.7	3	1.1	0.5	5	1.6	0.8	11	1.3	0.6	0.7	0	0.3	0.3
Hirundo cucullata	Greater striped swallow	I	R	A	0	0	0	0	0	0	11	3.5	1.7	11	1.3	0.6	22		5.5 -	5.5 -

Table A1. *Cont.*

Scientific Species Name	Common Species Name	Guilds			DCT, 28 km			WCT, 27 km			MFT, 31 km			Total			χ^2 test			
		Fe	Ne	Fo	n	d	%d	n	d	%d	n	d	%d	n	d	%d	1/2/3	1/2	1/3	2/3
Pternistes swainsonii	Swainson's spurfowl	G	G	G	5	1.8	1.2	6	2.2	1	0	0	0	11	1.3	0.6	5.6	0	2.5	3
Tricholaema leucomelas	Acacia pied barbet	F	H	T	1	0.4	0.2	10	3.7	1.6	0	0	0	11	1.3	0.6	16.5	3.7	0.5	5.0 -
Buteo rufofuscus	Jackal buzzard	C	R	P	0	0	0	0	0	0	9	2.9	1.4	9	1	0.5	18		4.5 -	4.5 -
Eupodotis caerulescens	Blue korhaan	I	G	G	9	3.2	2.1	0	0	0	0	0	0	9	1	0.5	18	4.5 -	4.5 -	
Oena capensis	Namaqua dove	G	T	G	3	1.1	0.7	5	1.9	0.8	0	0	0	8	0.9	0.5	4.8	0.25	1.5	2.5
Prinia flavicans	Black-chested prinia	I	V	V	0	0	0	8	3	1.3	0	0	0	8	0.9	0.5	16	4		4
Vidua macroura	Pin-tailed whydah	G	T	G	0	0	0	8	3	1.3	0	0	0	8	0.9	0.5	16	4 -		4.0 -
Hirundo albigularis	White-throated swallow	I	R	A	0	0	0	0	0	0	7	2.3	1.1	7	0.8	0.4	14		3.5	3.5
Acrocephalus baeticatus	African reed warbler	I	V	V	0	0	0	6	2.2	1	0	0	0	6	0.7	0.3	12	3		3
Scleroptila levaillantoides	Orange River francolin	G	T	G	5	1.8	1.2	1	0.4	0.2	0	0	0	6	0.7	0.3	7	1.3	2.5	0.5
Charadrius tricollaris	Three-banded plover	I	G	G	5	1.8	1.2	0	0	0	0	0	0	5	0.6	0.3	10	2.5	2.5	
Chrysococcyx caprius	Diederick cuckoo	I	T	T	5	1.8	1.2	0	0	0	0	0	0	5	0.6	0.3	10	2.5	2.5	
Euplectes ardens	Red-collared widowbird	G	V	V	0	0	0	0	0	0	5	1.6	0.8	5	0.6	0.3	10		2.5	2.5
Nectarinia famosa	Malachite sunbird	N	T	V	0	0	0	0	0	0	5	1.6	0.8	5	0.6	0.3	10		2.5	2.5
Anthus chloris	Yellow-breasted pipit	I	G	V	0	0	0	0	0	0	4	1.3	0.6	4	0.5	0.2	8		2	2
Apus caffer	White-rumped swift	I	R	A	0	0	0	0	0	0	4	1.3	0.6	4	0.5	0.2	8		2	2
Scleroptila africanus	Grey-winged francolin	G	G	G	0	0	0	0	0	0	4	1.3	0.6	4	0.5	0.2	8		2	2
Sigelus silens	Fiscal flycatcher	I	T	T	0	0	0	4	1.5	0.6	0	0	0	4	0.5	0.2	8	2		2
Trachyphonus vaillantii	Crested barbet	F	H	T	0	0	0	4	1.5	0.6	0	0	0	4	0.5	0.2	8	2		2
Bostrychia hagedash	Hadada ibis	I	T	G	1	0.4	0.2	0	0	0	2	0.6	0.3	3	0.3	0.2	2	0.5	0.2	1
Colis colius	White-backed mousebird	F	T	T	0	0	0	3	1.1	0.5	0	0	0	3	0.3	0.2	6	1.5		1.5
Columba guinea	Speckled pigeon	G	R	G	0	0	0	0	0	0	3	1	0.5	3	0.3	0.2	6		1.5	1.5
Crithagra atrogularis	Black-throated canary	G	T	T	0	0	0	3	1.1	0.5	0	0	0	3	0.3	0.2	6	1.5		1.5
Hirundo fuligula	Rock martin	I	R	A	0	0	0	0	0	0	3	1	0.5	3	0.3	0.2	6		1.5	1.5
Lanis collaris	Common fiscal	I	T	P	2	0.7	0.5	1	0.4	0.2	0	0	0	3	0.3	0.2	2	0.2	1	0.5
Passer melanurus	Cape sparrow	G	T	G	0	0	0	1	0.4	0.2	2	0.6	0.3	3	0.3	0.2	2	0.5	1	0.2
Batis pririt	Pirit batis	I	T	T	0	0	0	2	0.7	0.3	0	0	0	2	0.2	0.1	4	1		1
Cercotrichas paena	Kalahari scrub robin	I	T	T	0	0	0	2	0.7	0.3	0	0	0	2	0.2	0.1	4	1		1
Corvus capensis	Black crow	C	T	P	0	0	0	0	0	0	2	0.6	0.3	2	0.2	0.1	4		1	1
Crithagra flaviventris	Yellow canary	G	T	T	0	0	0	1	0.4	0.2	1	0.3	0.2	2	0.2	0.1	1	0.5	0.5	0
Emberiza tahapisi	Cinnamon-breasted bunting	G	R	G	1	0.4	0.2	1	0.4	0.2	0	0	0	2	0.2	0.1	1	0	0.5	0.5

Table A1. *Cont.*

Scientific Species Name	Common Species Name	Guilds			DCT, 28 km			WCT, 27 km			MFT, 31 km			Total			χ^2 test			
		Fe	Ne	Fo	n	d	%d	n	d	%d	n	d	%d	n	d	%d	1/2/3	1/2	1/3	2/3
Onychognathus morio	Red-winged starling	F	R	T	0	0	0	0	0	0	2	0.6	0.3	2	0.2	0.1	4		1	1
Quelea quelea	Red-billed quelea	G	T	V	0	0	0	2	0.7	0.3	0	0	0	2	0.2	0.1	4	1		1
Rhinopomastes cyanomelas	Common scimitarbill	I	H	T	0	0	0	2	0.7	0.3	0	0	0	2	0.2	0.1	4	1		1
Scopus umbetta	Hamerkop	C	T	P	2	0.7	0.5	0	0	0	0	0	0	2	0.2	0.1	4	1	1	
Anthus crenatus	African rock pipit	I	R	G	0	0	0	0	0	0	1	0.3	0.2	1	0.1	0.1	2		0.5	0.5
Bubo capensis	Cape eagle owl	C	R	P	0	0	0	0	0	0	1	0.3	0.2	1	0.1	0.1	2		0.5	0.5
Burhinus capensis	Spotted thick-knee	I	G	G	0	0	0	1	0.4	0.2	0	0	0	1	0.1	0.1	2	0.5		0.5
Ceryle rudis	Pied kingfisher	C	H	P	0	0	0	0	0	0	1	0.3	0.2	1	0.1	0.1	2		0.5	0.5
Circus maurus	Black harrier	C	G	P	0	0	0	0	0	0	1	0.3	0.2	1	0.1	0.1	2		0.5	0.5
Circus ranivorus	African marsh harrier	I	V	P	0	0	0	0	0	0	1	0.3	0.2	1	0.1	0.1	2		0.5	0.5
Estrilda astrild	Common waxbill	G	V	V	0	0	0	0	0	0	1	0.3	0.2	1	0.1	0.1	2		0.5	0.5
Falco biarmicus	Lanner falcon	C	R	P	0	0	0	0	0	0	1	0.3	0.2	1	0.1	0.1	2		0.5	0.5
Gypaetus barbatus	Bearded vulture	C	R	P	0	0	0	0	0	0	1	0.3	0.2	1	0.1	0.1	2		0.5	0.5
Passer diffusus	Southern grey-headed sparrow	G	T	G	0	0	0	0	0	0	1	0.3	0.2	1	0.1	0.1	2		0.5	0.5
Prinia hypoxantha	Drakensberg prinia	I	V	V	0	0	0	0	0	0	1	0.3	0.2	1	0.1	0.1	2		0.5	0.5
Rhinoptilus africanus	Double-banded courser	I	G	G	0	0	0	0	0	0	1	0.3	0.2	1	0.1	0.1	2		0.5	0.5
Streptopelia semitorquata	Red-eyed dove	G	T	T	0	0	0	1	0.4	0.2	0	0	0	1	0.1	0.1	2	0.5		0.5
Sylvia subcaeruleum	Chestnut-vented tit-babbler	I	T	T	0	0	0	1	0.4	0.2	0	0	0	1	0.1	0.1	2	0.5		0.5
Urocolis indicus	Red-faced mousebird	F	T	T	0	0	0	1	0.4	0.2	0	0	0	1	0.1	0.1	2	0.5		0.5

References

1. Smith, R.L. *Ecology and Field Biology*, 5th ed; Addison-Wesley Educational Publishers: Menlo Park, CA, USA, 1996.
2. Hoekstra, J.M.; Boucher, T.M.; Ricketts, T.H.; Roberts, C. Confronting a biome crisis: Global disparities of habitat loss and protection. *Ecol. Lett.* **2005**, *8*, 23–29. [CrossRef]
3. Douglas, D.J.; Waldinger, J.; Buckmire, Z.; Gibb, K.; Medina, J.P.; Sutcliffe, L.; Beckmann, C.; Collar, N.J.; Jansen, R.; Kamp, J.; et al. A global review identifies agriculture as the main threat to declining grassland birds. *Ibis* **2023**, *165*, 1107–1128. [CrossRef]
4. Azpiroz, A.B.; Isacch, J.P.; Dias, R.A.; Di Giacomo, A.S.; Fontana, C.S.; Palarea, C.M. Ecology and conservation of grassland birds in southeastern South America: A review. *J. Field Orn.* **2012**, *83*, 217–246. [CrossRef]
5. Vickery, P.D.; Herkert, J.R. (Eds.) Ecology and conservation of grassland birds of the Western Hemisphere. In *Studies in Avian Biology*; Cooper Ornithological Society: Chicago, IL, USA, 1999; Volume 19, pp. 1–299.
6. Scholtz, R.; Twidwell, D. The last continuous grasslands on Earth: Identification and conservation importance. *Conserv. Sci. Pract.* **2022**, *4*, e626. [CrossRef]
7. Kopij, G. Birds of the Bloemfontein area, Free State Province, South Africa, during the years 1977–2000: An overview. *Acta Zool. cracov.* **2019**, *62*, 41–76. [CrossRef]
8. De Swardt, D.H. Birds of the Bloemfontein pentad 2905_2610: A review over a 30 year period. *Biodiv. Observ.* **2017**, *8*, 43. [CrossRef]
9. Kopij, G. Birds of the western part of the Dewetsdorp district, Free State. *Mirafra* **2001**, *18*, 1–16.
10. Maphisa, D.H.; Smit-Robinson, H.; Underhill, L.G.; Altwegg, R. Drivers of bird species richness within moist high-altitude grasslands in eastern South Africa. *PLoS ONE* **2016**, *11*, e0162609. [CrossRef]
11. Maphisa, D.H.; Smit-Robinson, H.; Underhill, L.G.; Altwegg, R. Management factors affecting densities of common grassland birds of high elevation grasslands of eastern South Africa: Ingula as a case study. *Avian Res.* **2017**, *8*, 5. [CrossRef]

12. Kopij, G. Die Vogelgemeinschaft des afromontanen *Themeda-Festuca* Graslandes der endemitenreichen Drakensberg-Region, Südafrica. *Orn. Mit.* **2014**, *66*, 99–107.
13. Kopij, G. The birds of Sehlabathebe National Park, Lesotho. *Koedoe* **2002**, *45*, 65–78. [CrossRef]
14. Kopij, G. Avian assemblages in the area around Thabana Ntlenyana, the highest peak of Southern Africa, 2010. *Zesz. Nauk. AR Wroclaw* **2010**, *60*, 67–75.
15. Kopij, G. Avian assemblages in Afro-mountain and Alti-mountain Grasslands in the endemic Maloti/Drakensberg region of Lesotho. *Zool. Ecol.* **2015a**, *25*, 319–326. [CrossRef]
16. Thomas, V.; Grant, R. *Highveld and the Drakensberg*; Jacana: Johannesburg, South Africa, 2004.
17. Rutherford, M.C.; Mucina, L.; Powrie, L.W. Biomes and Bioregions of Southern Africa. *Sterlizia* **2006**, *19*, 1–51.
18. Sutherland, W.J. *Ecological Census Techniques: A Handbook*; Cambridge University Press: Cambridge, UK, 1996.
19. Bibby, C.J.; Burgess, N.D.; Hill, D.A.; Mustoe, S. *Bird Census Techniques*, 2nd ed; Academic Press: London, UK, 2000.
20. Clements, J.F.; Schulenberg, T.S.; Iliff, M.J.; Roberson, D.; Fredericks, T.A.; Sulivan, B.L.; Wood, C.L. The eBird/Clements Checklist of Birds of the World. 2018. Available online: http://www.birds.cornell.edu/clementschecklist/download (accessed on 29 October 2025).
21. Gottschalk, T.K.; Ekschmitt, K.; Bairlein, F. Relationships between vegetation and bird community composition in grasslands of the Serengeti. *Afr. J. Ecol.* **2007**, *45*, 557–565. [CrossRef]
22. Shaffer, J.A.; DeLong, J.P. *The Effects of Management Practices on Grassland Birds—An Introduction to North American Grasslands and the Practices Used to Manage Grasslands and Grassland Birds*; Geological Survey Professional Paper 1842; U.S. Geological Survey: Jamestown, ND, USA, 2019. [CrossRef]
23. Boyce, A.J.; Shamon, H.; Kunkel, K.E.; McShea, W.J. Grassland bird diversity and abundance in the presence of native and non-native grazers. *Avian Conserv. Ecol.* **2021**, *16*, 13. [CrossRef]
24. Billinger, E.K. Successful changes and habitat selection in hayfield bird communities. *Auk* **1995**, *112*, 720–730.
25. MacMaster, D.G.; Dervies, J.H.; Davis, S.K. Grassland birds nesting in hay lands of southern Saskatchewan: Landscape influences and conservation priorities. *J. Wildl. Mgmt.* **2005**, *69*, 211–221. [CrossRef]
26. Kopij, G. Avian diversity in an urbanized South African grassland. *Zool. Ecol.* **2015**, *25*, 87–100. [CrossRef]
27. Kopij, G. Population Densities and Community Structure of Birds Breeding in a Suburban Wooded Grassland in the Highveld of Lesotho. *Vest. Zool.* **2019**, *53*, 155–164. [CrossRef]
28. Hamer, T.L.; Flather, C.H.; Noon, B.R. Factors associated with grassland bird species richness: The relative roles of grassland area, landscape structure, and prey. *Landsc. Ecol.* **2006**, *21*, 569–583. [CrossRef]
29. Dunning, J.B., Jr. Shrub-steppe bird assemblages revisited: Implications for community theory. *Am. Nat.* **1986**, *128*, 82–98. [CrossRef]
30. Chapman, R.N.; Engle, D.M.; Masters, R.E.; Leslie, D.M., Jr. Grassland vegetation and bird communities in the southern Great Plains of North America. *Agric. Ecosyst. Environ.* **2004**, *104*, 577–585. [CrossRef]
31. Isacch, J.P.; Maceira, N.O.; Bo, M.S.; Demaría, M.R.; Peluc, S. Bird-habitat relationship in semi-arid natural grasslands and exotic pastures in the west pampas of Argentina. *J. Arid Environ.* **2005**, *62*, 267–283. [CrossRef]
32. Becker, R.G.; Paise, G.; Pizo, M.A. A comparison of bird communities in natural and revegetated grasslands in south Brazil. *Rev. Brasil. Orn.* **2019**, *27*, 199–206. [CrossRef]
33. Wiens, J.A. Climatic instability and the 'ecological saturation' of bird communities in North American grasslands. *Condor* **1974**, *76*, 385–400. [CrossRef]
34. Cody, M.L. *Competition and the Structure of Bird Communities*; Princeton University Press: Princeton, USA, 1974.
35. Dickinson, M.D. (Ed.) *Field Guide to Birds of North America*, 4th ed; National Geographic Society: Washington, DC, USA, 2002.
36. Snow, D.W.; Perrins, C.M. *The Birds of the Western Palearctic*; Oxford University Press: Oxford, UK, 1998.
37. Hockey, P.A.R.; Dean, W.R.J.; Ryna, P.G. (Eds.) *Roberts' Birds of Southern Africa*, 7th ed; John Voelcker Bird Book Fund: Cape Town, South Africa, 2005.
38. Kopij, G. The birds of Bloemspruit, Bloemfontein. *Mirafra* **1997**, *14*, 8–12.
39. Kopij, G. Breeding density of Fiscal Shrike (*Lanius collaris*). *Biol. Lett.* **2004**, *41*, 77–85.
40. Kopij, G. Bird communities of suburb habitats in South African Highveld during the wet and dry season. *Zesz. Nauk. AR Wroc.* **2004**, *50*, 205–211.
41. Browder, S.F.; Johnson, D.H.; Ball, I.J. Assemblages of breeding birds as indicators of grassland condition. *Ecol. Indic.* **2002**, *2*, 257–270. [CrossRef]
42. Lee, A.T.K.; Rose, S.; Banda, S.; Bezeng, S.B.; Maphalala, M.I.; Maphisa, D.H.; Smit-Robinson, H.A. (Eds.) *The 2025 Red Data Book of Birds of South Africa, Lesotho and Eswatini*; BirdLife South Africa: Johannesburg, South Africa, 2025.
43. SANBI. *Grazing and Burning Guidelines: Managing Grasslands for Biodiversity and Livestock Production*; South African National Biodiversity Institute: Pretoria, South Africa, 2014.

44. Vickery, P.D.; Tubaro, P.L.; Maria Cardosa da Silva, J.; Peterson, B.G.; Herkert, J.R.; Cavalcanti, R.B. Introduction: Conservation of Grassland Birds in the Western Hemisphere. *Stud. Avian Biol.* **1999**, *19*, 4.
45. Vaccaro, A.S.; Filloy, J.; Bellocq, M.I. What land use better preserves taxonomic and functional diversity of birds in a grassland biome? *Avian Conserv. Ecol.* **2019**, *14*, 1. [CrossRef]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.