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Comparing bird sightings between grassland and marsh habitats at a rehabilitated wetland in Gauteng Province, South Africa

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Abstract. *Botha J, Haussmann NS. 2023. Comparing bird sightings between grassland and marsh habitats at a rehabilitated wetland in Gauteng Province, South Africa. Biodiversitas 24: 3536-3542.* Wetlands, including rehabilitated wetlands, form important feeding and nesting sites for a large range of bird species. The restoration of degraded wetlands is therefore important from a bird biodiversity perspective and bird surveys are needed in such systems. However, bird counts typically differ both spatially (e.g., between different habitats within the wetland) and temporally (e.g., between different seasons or times of the day). This study compared bird sightings at a rehabilitated wetland in the Gauteng Province of South Africa between marsh and grassland sections of the wetland and between morning and afternoon sessions. A total of 47 bird species were sighted at the wetland, including a number of species that have been listed as declining. Whereas more species were sighted in the marsh habitats of the wetland than the grassland habitats, differences in the number of sightings between habitats depended on the time of day. Thus, although there were no differences in the number of sightings between morning and afternoon sessions at the marshes, the number of sightings was higher in the afternoons than in the mornings at the grasslands. We therefore, first caution against comparing bird counts, in general, between studies conducted at different times of the day. More importantly, however, our results highlight the importance of not only conserving natural, pristine wetlands but also rehabilitated wetlands to create habitats for declining bird populations in transformed environments such as urban settings.

Keywords: Bird, birder, grassland, marsh, wetland

INTRODUCTION

Wetlands, which occupy approximately 6% of the global surface area (Junk et al. 2013), face a number of threats, such as invasions by alien plant species, pollution and urban development (Gopal 2013; Junk et al. 2013; Davidson 2014). Despite being threatened, the vast majority of global wetlands remain unprotected (Reis et al. 2017). In South Africa, specifically, between 35% and 60% of the original wetland areas are estimated to have been lost or severely degraded by 2011, with approximately 70% of the remaining wetlands remaining unprotected and only 2.4% of the country's surface area currently classified as wetland (Department of Forestry, Fisheries and the Environment of South Africa/DFFE, n.d.). Wetlands are, however, important due to the ecosystem services that they provide, such as flood control, drought relief and water purification (Mitsch and Hernandez 2013).

Wetlands are also important habitats for a large range of bird species. Due to the patchiness of wetlands (i.e., the interspersed vegetation patches and open water areas), aquatic bird species thrive in wetlands (Kačergytė et al. 2021). In general, the number of bird species sighted, which species are sighted and their abundances vary both spatially (e.g., between habitat types) and temporally (i.e., seasonally and diurnally), depending on resource availability and phenological changes (Ronchi-Virgolini et al. 2013; Soendjoto et al. 2018; Lee and Kang 2019). In wetlands, factors that influence bird compositions include the water body characteristics (depth and size), food availability, and the presence and abundance of viable breeding and resting sites (Ronchi-Virgolini et al. 2013; Saini et al. 2017; Daniel et al. 2021; Farley et al. 2022).

A number of metrics can be calculated to provide information on biological diversity and abundance (Goudarzian and Erfanifard 2017; Magurran 2021; Roswell et al. 2021). For example, species richness (i.e., how many species) gives information on the diversity of a site, as does the composition (i.e., which species) and the relative contributions of species (i.e., species evenness). The number of individuals sighted within a species (i.e., how many are seen) gives information on population sizes, as does the number of sightings (i.e., how often it is seen). The number of sites where a species is present says something about how widespread the species is and whether the species is associated with a specific environment. Lastly, species rarefaction curves (i.e., the increase in new species with increasing sampling effort) tell us something about the relative contribution of common versus rare species to the species assemblage. When measured over larger spatial and temporal scales, these indices and how they change both spatially and temporally can inform ecological management decisions (Goudarzian and Erfanifard 2017; Roswell et al. 2021). However, over shorter spatial and temporal scales, they also provide practical information to birders - i.e., people that spot birds as a hobby - such as when and where the largest number of species can be seen, or when and where a species can be seen most frequently.

Gauteng Province is the smallest but most densely populated province of South Africa. It houses both the largest city in the country, Johannesburg, as well as the country's administrative capital, Pretoria. Savanna vegetation dominates the north of the province, whereas the central and southern regions - where this study was undertaken - fall under the grassland biome (Mucina et al. 2014). Although the province in general is a built-up, urbanized environment, forming the economic hub of the country, there are pockets of smaller nature reserves and conservation areas scattered throughout the province. In an urban setting such as Gauteng, which experiences many human-associated threats to ecosystem integrity (Cadman et al. 2013), such remnant conservation patches are becoming increasingly important for biodiversity conservation. In addition to preservation, rehabilitation can also play an important conservation role in degraded environments. For example, Soendjoto et al. (2018) showed that the number of bird species increased over time in a reclaimed coal mine site in Indonesia, as the positive effects of revegetation increased. Similarly, a number of studies suggest that restored (Farley et al. 2021) and even created wetlands (Kačergytė et al. 2021) have conservation value, although not always to the same extent as natural wetlands (Saini et al. 2017).

This study aimed to investigate the spatial and temporal dynamics that influence bird sightings by using a rehabilitated wetland in Gauteng Province, South Africa, as a case study. Three research questions were asked, namely: 1) Do the number of bird species sighted over a five-day period differ between habitat types (grassland vs. marsh) or between times of the day (morning vs. afternoon)?; 2) Are any of the bird species associated with either of the two habitat types or times of day at the wetland?; and 3) How do habitat type and time of day influence the number of bird sightings for the common bird species?

MATERIALS AND METHODS

Study area

This study was conducted in Ebotse Golf and Country Estate, which is approximately 55 km southeast of Pretoria and 45 km east of Johannesburg in Gauteng Province, South Africa (Figure 1). The area receives most of its rainfall (between 600 and 800 mm annually) during the summer months, between December and January. Summers are warm, with an average December maximum of approximately 26°C, whereas winters are cool during the day (mean June maximum of approximately 17°C) and cold at night (mean minimum of approximately 4°C) (Kruger and Mbatha 2021). The marsh areas of the wetlands are dominated by reeds (*Phragmites australis*), whereas invasive pampas grasses (*Cortaderia selloana*) are still abundant in the grassland sections.

Large portions of Ebotse were developed on an old, decommissioned sand quarry, which was operational from the 1970s until the early 2000s. The quarrying and associated construction affected the wetlands and surroundings at Ebotse in the form of vegetation destruction through the vehicle and human traffic, as well as increased dust emissions from construction. After the sand quarrying ceased, attempts at rehabilitating the cluster of 23 wetlands at Ebotse and the Rynfield Dam - which used to be a slimes dam - started in 2005. Active restoration of the slimes dam, as well as allowing the surrounding marsh areas to recover passively, has led to an increase in the sightings of bird, fish and amphibian species (Chown P 2022, pers. com.). Thus, some positive strides have been made toward restoring biodiversity in the wetlands. The estate now not only attracts golfers, but the number of birders has also increased steadily since the restoration efforts first began.

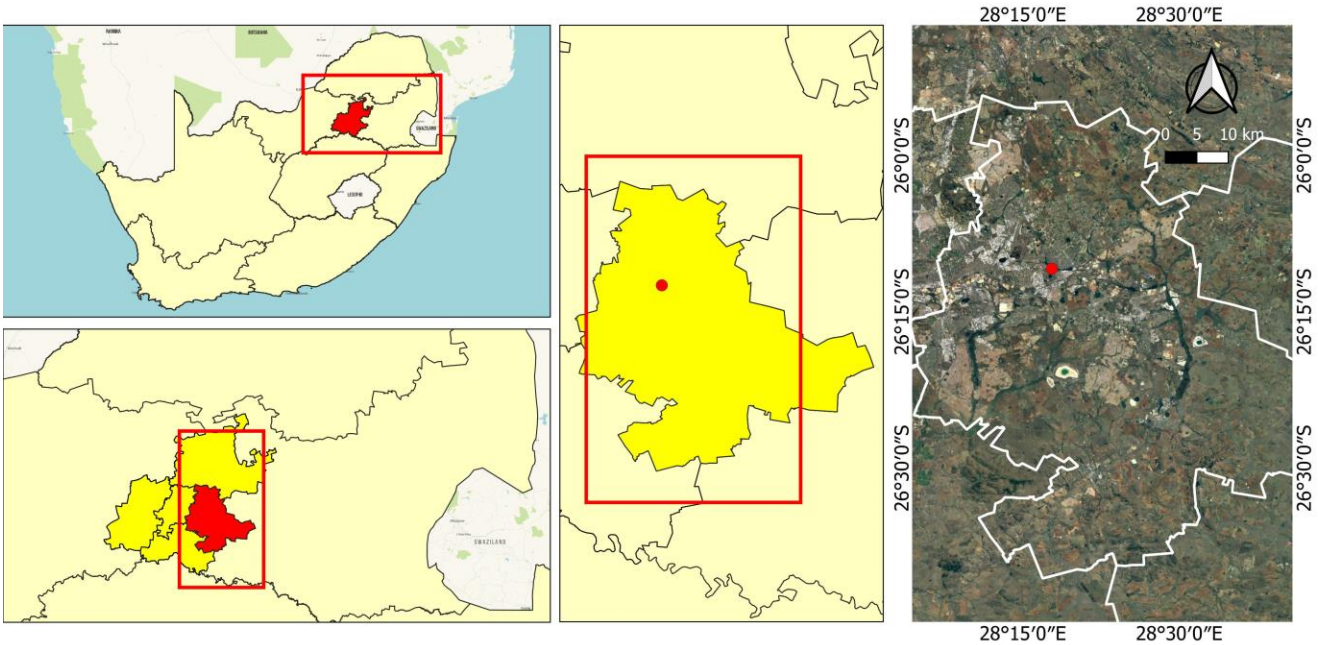

Figure 1. Location of Ebotse Golf and Country Estate in South Africa (*left*) and Gauteng Province (*right*)

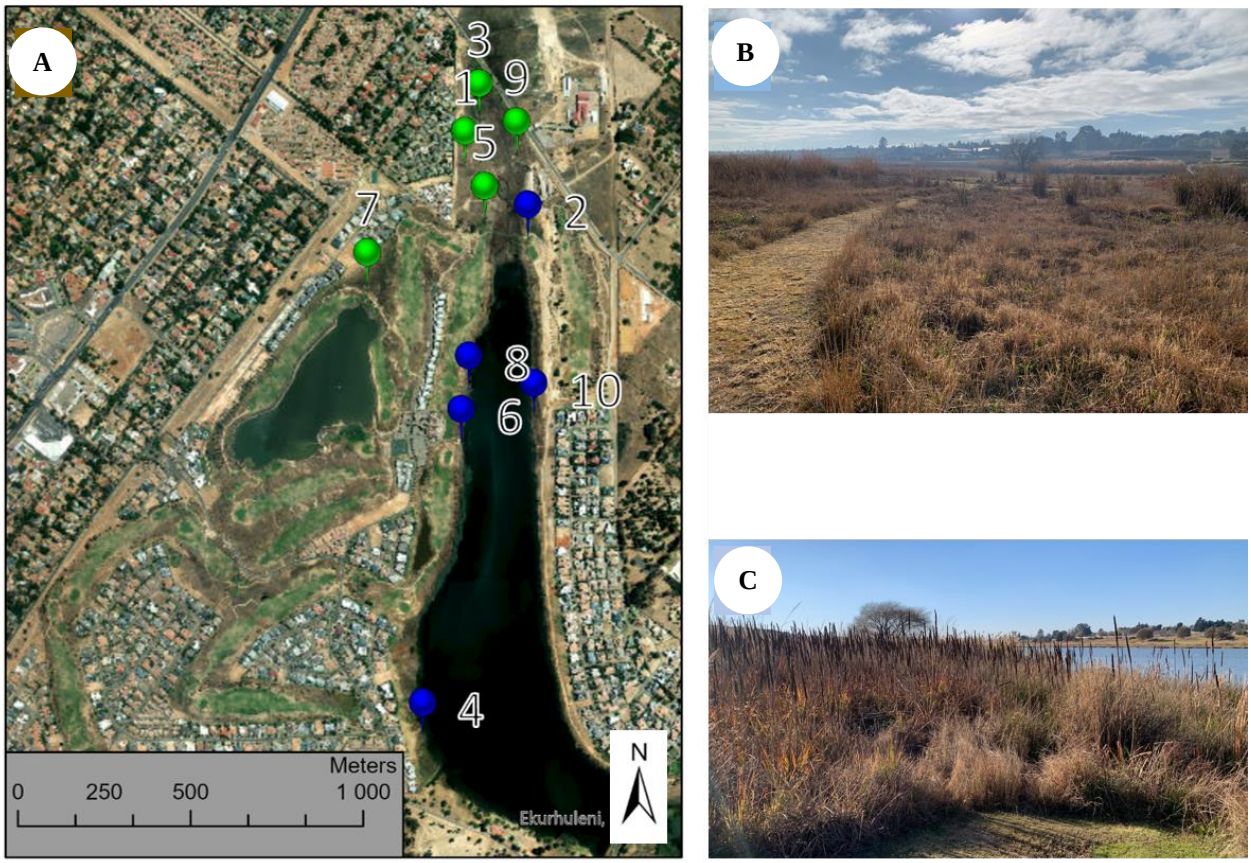

Figure 2. The ten survey sites at Ebotse (2.A), with green symbols (odd numbers) indicating grassland sites (e.g., 2.B) and blue symbols (even numbers) indicating marsh sites (e.g., 2.C). (Google Earth Pro (2023) Ebotse Golf and Country Estate 26°9'S, 28°21'E, elevation 1619m [online] Available at: http://www.earth.google.com [Accessed 19 June 2023]

Sampling design and data collection

Ten sample sites were selected at Ebotse, five from the grassland and five from the marsh habitats (Figure 2). The exact observation point at each site, where a Geographic Positioning System (GPS) coordinate was recorded, was surrounded by at least 50 m of grassland or marsh habitat respectively and individual sampling sites were at least 100 m apart from one another to approximate independence (following Subasinghe and Sumanapala 2014). However, we acknowledge that, for species with large home ranges, this distance might not be sufficient to achieve complete independence (Mattos and Peris 2008).

The fieldwork was conducted over ten days during the Austral winter (from 6 June 2022 until 1 July 2022). We used 3-hour point count sessions to record birds at each of the ten sites, alternating daily between grassland and marsh sites. Observations were taken during two intervals (morning: 09:00-12:00 and afternoon: 15:00-18:00) on each day and only on days with no cloud cover. During the observation sessions, all birds seen by the first author to land within an estimated 50 m radius of the author were recorded. For each bird sighted, the species was recorded, as well as the time of day that it was observed. Birds that flew over the wetlands, but did not land, were not recorded in this study. All observations were made by the first author and the first author alone.

Data analysis

The effects of habitat type, time of day and their interactions on the number of sighted species and the number of sightings - both total numbers and per species - were studied using generalized linear models (GLMs) and assuming a Poisson distribution. For the number of sightings per individual species, only the commonly occurring species (>15 sightings) were modeled. In addition, Fisher exact tests of association were used to determine whether bird presence was associated with habitat type (grassland or marsh) or time of day (morning vs afternoon) for any of the bird species. All statistical analyses were conducted in R (version 3.1.1, R Development Core Team, 2013).

RESULTS AND DISCUSSION

In total, 47 bird species were sighted at the Ebotse wetlands over the five-day period. The African Stonechat (*Saxicola torquatus*) was the most widespread and most frequently sighted species, occurring at all of the sites, both in the grasslands and marshes and spotted more than 90 times across both sites (Table 1). The majority of the species (45 of 47) were native to South Africa, but none of them were of conservation concern (conservation status of "least concern", IUCN Version 2022.2).

The average number of species sighted per day differed significantly between the two habitats, with five more species sighted on average in the morning, and two more in the afternoon, at the marshes than at the grasslands (Table 2). As a result, eight more species were sighted in the marsh habitats in total (37 species) compared to the grassland habitats (29 species) (Table 1). In contrast to habitat, time of day did not have a significant effect on the number of species spotted and one is therefore likely to see an equal number of species during morning and afternoon bird-watching sessions at Ebotse (Table 2). Thus, the majority of the species that were sighted in the morning were also sighted in the afternoon and none of the species were significantly associated with a time of day (Table 1).

Table 1. The 47 bird species were seen across all ten sites. The values are the number of sites where the species was present (maximum 5 for each habitat type), as well as the total number of sightings for the species across all ten sites. Species that were significantly associated with either habitat, based on Fisher exact tests, are indicated with an asterisk(s). Introduced species are indicated in bold

Species	Grassland		Marsh		Total sightings
	Morning	Afternoon	Morning	Afternoon	
African Darter (*Anhinga rufa)*	0	0	1	1	3
African Sacred Ibis (*Threskiornis aethiopicus*)	0	0	1	1	4
African Stonechat (*Saxicola torquatus*)	4	5	5	5	93
Black Sparrowhawk (*Accipiter melanoleucus*)	1	0	0	0	1
Black-headed Heron (*Ardea melanocephala*)	1	1	2	0	4
Blacksmith Lapwing (*Vanellus armatus*)	3	2	4	2	21
Black-winged Kite (*Elanus caeruleus*)	2	1	1	0	4
Cape Glossy Starling (*Lamprotornis nitens*)	1	1	0	0	2
Cape Sparrow (*Passer melanurus*)	2	1	1	0	11
Cape Turtle Dove (*Streptopelia capicola*)	3	4	2	0	17
Cape Wagtail (*Motacilla capensis*)	1	0	0	0	1
Cape Weaver (*Ploceus capensis*)	0	0	1	0	1
Capped Wheatear (*Oenanthe pileata*)	1	0	0	0	1
Common Moorhen (*Gallinula chloropus*)	0	0	1	1	3
Dark-Capped Bulbul (*Pycnonotus tricolor*)	1	3	0	0	8
Desert Cisticola (*Cisticola aridulus*)	1	2	3	3	23
Domestic Goose (*Anser anser domesticus*)	0	0	2	1	4
Egyptian Goose (*Alopochen aegyptiaca*)	0	0	3	3	9
Fiscal Flycatcher (*Sigelus silens*)	0	1	1	0	2
Fulvous Whistling Duck *(Dendrocygna bicolor)*	0	0	0	1	1
Goliath Heron (*Ardea goliath*)	0	0	1	1	2
Grey-headed Gull (*Chroicocephalus cirrocephalus*)	0	0	1	0	1
Hadada Ibis *(Bostrychia hagedash)*	2	1	1	1	8
Helmeted Guineafowl (*Numida meleagris*)	2	1	0	1	7
House Sparrow (*Passer domesticus*)	**2**	**2**	**1**	**1**	**16**
Indian Myna (*Acridotheres tristis*)	**0**	**2**	**0**	**3**	**10**
Levaillant's Cisticola (*Cisticola tinniens*)	1	3	1	1	6
Little Grebe (*Tachybaptus ruficollis*)	0	0	3	3	13
Little Rush Warbler (*Bradypterus baboecala*)	1	0	0	0	1
Malachite Kingfisher (*Corythornis cristatus*)	0	0	0	1	1
Melodious Lark (*Mirafra cheniana*)	0	1	0	0	1
Pied Kingfisher (*Ceryle rudis*) *	0	0	4	1	5
Pin-tail Whydah (*Vidua macroura*)	0	2	0	0	3
Red-Chested Flufftail (*Sarothrura rufa*)	1	2	1	0	12
Red-knobbed Coot (*Fulica cristata*) **	0	0	5	5	38
Reed Cormorant (*Microcarbo africanus*)	0	0	3	3	11
Southern Anteating-chat (*Myrmecocichla formicivora*)	0	1	0	0	1
Southern Fiscal (*Lanius collaris*)	2	2	1	0	6
Southern Masked Weaver (*Ploceus velatus*)	2	3	3	3	34
Southern Pochard (*Netta erythrophthalma*)	0	0	2	0	6
Southern Red Bishop (*Euplectes orix*)	1	1	1	2	15
Speckled Pigeon (*Columba guinea*)	0	0	0	1	1
Thick-Billed Weaver (*Amblyospiza albifrons*)	1	0	0	0	1
Village Weaver (*Ploceus cucullatus*)	0	0	0	1	1
White-Breasted Cormorant (*Phalacrocorax lucidus*)	0	0	1	2	3
White Throated Swallow (*Hirundo albigularis*)	0	0	1	1	1
Yellow Bishop (*Euplectes capensis*)	1	1	1	1	22

Note: Significance codes: * < 0.05, ** < 0.01

Table 2. Mean±SD for the number of species sighted, total sightings as well as the sightings of the nine commonly occurring (> 15 sightings) species in the grasslands and the marshes. The table also shows the GLM results. Significant relationships are indicated in bold ($p < 0.05$).

Response variable	Grasslands		Marshes		Z			*p*		
	Morning	Afternoon	Morning	Afternoon	Time of Day	Habitat	Interact-ion	Time of Day	Habitat	Interact-ion
Number of species	**7.4±1.52**	**8.4±1.52**	**12.4±2.41**	**10.2±2.17**	**0.48**	**15.31**	**3.40**	**0.50**	**<0.01**	**0.08**
Total sightings	**16.4±5.59**	**25.4±11.22**	**26.0±3.54**	**24.8±6.02**	**1.48**	**1.97**	**2.53**	**0.24**	**0.18**	**<0.01**
African Stonechat (*Saxicola torquatus*)	4.8±3.26	6.6±3.26	4.0±1.45	3.8±1.45	0.43	2.18	0.67	0.52	0.16	0.42
Blacksmith Lapwing (*Vanellus armatus*)	0.8±1.22	1.0±1.22	1.4±1.17	1.0±1.17	0.03	0.26	0.26	0.87	0.62	0.62
Cape Turtle Dove (*Streptopelia capicola*)	**1.2±1.02**	**1.8±1.02**	**0.4±0.40**	**0.0±0.40**	**0.07**	**12.52**	**1.85**	**0.79**	**< 0.01**	**0.19**
Desert Cisticola (*Cisticola aridulus*)	0.2±2.68	2.2±2.68	0.6±1.70	1.6±1.70	2.05	0.01	0.23	0.17	0.93	0.64
House Sparrow (*Passer domesticus*)	0.6±1.79	1.4±1.79	1.0±1.50	0.2±1.50	0.00	0.25	1.00	1.00	0.62	0.33
Red-knobbed Coot (*Fulica cristata*)	**0.0**	**0.0**	**3.4±1.40**	**4.2±1.40**	**0.71**	**64.18**	**0.71**	**0.41**	**<0.001**	**0.41**
Southern Masked Weaver (*Ploceus velatus*)	1.0±1.95	1.6±1.95	2.2±2.26	2.0±2.26	0.04	0.58	0.15	0.85	0.46	0.71
Southern Red Bishop (*Euplectes orix*)	0.6±1.20	0.6±1.20	1.2±1.81	0.6±1.81	0.16	0.16	0.16	0.70	0.70	0.70
Yellow Bishop (*Euplectes capensis*)	1.6±3.63	2.0±3.63	0.2±0.92	0.6±0.92	0.09	1.13	0.00	0.77	0.30	1.00

A number of bird species were seen exclusively in either of the two habitats, but were not seen at many sites, and these differences are therefore not statistically significant (e.g., the Egyptian Goose (*Alopochen aegytiaca*) at the marshes (as well as a number of other water bird species) and the Dark-capped Bulbul (*Pycnonotus tricolor*) at the grasslands). However, two species were significantly associated with habitat, namely the Pied Kingfisher (*Ceryle rudis*) and Red-knobbed Coot (*Fulica cristata*) (Table 1). Both of these were associated with the marsh sites - i.e., and they were present at a significantly larger number of marsh sites than grassland sites. Both of these birds are water birds, using dams and other water sources for feeding and/or nesting (Hockey et al. 2005) and it is therefore not surprising that they were only seen at the marshes. Water availability is known to be an important factor in determining bird population characteristics, with water area playing a particularly important role in affecting the structure of bird diversity and abundance (Malekian et al. 2022). However, when creating artificial wetlands, instead of one large wetland, many smaller wetlands interspersed with more terrestrial habitats, such as the grassland sections in this study, can increase overall bird species richness by increasing landscape heterogeneity (Kačergytė et al. 2021). At Ebotse, the grassland sections are in close proximity to the marshes and many species are seen in both habitats, but, as expected, species that require an aquatic habitat for feeding and nesting are mostly exclusive to the marsh sites adjacent to the water. From a bird-watching perspective, birders at wetlands with interspersed patches of grassland, such as Ebotse, are therefore likely to be more successful in seeing additional species - albeit mostly water bird species - at the marsh sections of the wetland, compared to the grassland sections in between.

A number of previous studies have shown that time of day has an effect on bird counts (O'Leske et al. 1997; Mattos and Peris 2008; De-pin et al. 2014), with varying outcomes. De-pin et al. (2014) found that counts were highest after 16:00 for wintering water birds at a lake in China and attributed this to human activity in the morning. In contrast, Rollfinke and Yahner (1990) recorded fewer winter bird sightings in the afternoons in a Pennsylvanian forest but noted that this was species-dependent. Similarly, O'Leske et al. (1997) found lower counts of fall bird species in an agricultural setting in Kansas in the afternoon. In this study, the effect of time of day on the number of bird sightings was dependent on habitat type (Table 2). Therefore, although one is likely to see birds equally often during morning and afternoon sessions at the marshes, in the grassland sites, afternoon bird watching is more effective in terms of the number of sightings than morning watching. In fact, of the eight frequently occurring bird species at the grasslands, seven were seen more often in the afternoon than in the morning, albeit not significantly so for any species individually (Table 2), suggesting an overall larger abundance of birds in the afternoon at the grasslands than in the morning. This trend also seems to apply to the less frequently sighted species - of the 28 species that were seen less than 15 times, 22 were seen more often in the afternoon than in the morning (results not shown). Our study took place in winter when the mornings are cold. We suggest that this possibly explains the increased number of sightings during the warmer afternoons in the grasslands. Our results also emphasize that the comparison of count surveys (e.g., to compare

habitats or sites) performed at different times of the day should be done cautiously.

Five days is a short period - we do not claim that our data are indicative of overall species richness or population size. In addition, the picture is likely to be quite different during summer, because of migration patterns. However, our study can provide information on when and where to spot birds on a very practical level, for example for birders. In summary, birders at Ebotse are likely to see more species at the marsh sites than at the grasslands. However, from a number of sightings perspective, habitat is not so important if afternoon bird watching is planned, but if morning bird watching is planned, the marsh sites are preferable. In addition, and more importantly, our results emphasize the importance of small, mixed-habitat wetlands in terms of bird conservation. Although none of the species were of conservation concern, the population trends for a number of the species sighted have been listed as declining (International Union for the Conservation of Nature, IUCN). For example, Black Sparrowhawk (*Accipiter melanoleucus*) populations in southern Africa are suffering from habitat loss and pesticide use (Ferguson-Lees and Christie 2001). Similarly, some studies suggest that the Melodious Lark (*Mirafra cheniana*) has contracted its range in southern Africa (Taylor et al. 2015). Our results show how, through rehabilitation, a once degraded slimes dam can be transformed into a heterogeneous landscape with a diverse array of habitat types, attracting declining bird species in an urban setting. Our results thus support previous studies that show that not only pristine wetlands have conservation value, but also manmade wetlands (Saini et al. 2017; Grundling et al. 2021), farm ponds (Froneman et al. 2001) and, in the case of this study, a rehabilitated wetland.

In conclusion, this study compared bird sightings between marsh and grassland sections, and between morning and afternoon observation sessions, at a rehabilitated wetland in Gauteng Province, South Africa. The results show that more species are seen in the marsh sections of the wetland than the grassland sections, as a result of an increased number of water bird species at the marshes. Furthermore, although the time of day does not affect the number of bird sightings at the marshes, birds are seen more frequently in the afternoons, compared to the mornings, at the grasslands. On a smaller, local scale, our results could inform bird-watching decisions, such as when and where the largest number of birds can be seen. More importantly, from a broader conservation-implication perspective, our results highlight the value of rehabilitation and restoration in hosting biodiversity, especially in degraded landscapes, such as urban environments.

REFERENCES

Cadman M, de Villiers C, Lechmere-Oertel R, McCulloch D. 2013. Grassland Ecosystem Guidelines: Landscape Interpretation for Planners and Managers. South African National Biodiversity Institute, Pretoria.

Daniel J, Polan H, Rooney RC. 2021. Determinants of wetland-bird community composition in agricultural marshes of the Northern Prairie and Parkland Region. Wetlands 41: 14. DOI: 10.1007/s13157-021-01409-6.

Davidson NC. 2014. How much wetland has the world lost? Long-term and recent trends in global wetland area. Mar Freshw Res 65: 936-941. DOI: 10.1071/MF14173.

Department of Forestry, Fisheries and the Environment of the Republic of South Africa. Working for Wetlands Programme. South Africa. https://www.dffe.gov.za/.

De-pin L, Gui-quan F, Ming-yang W, Zhi-hong Z, Rui-feng Y, Wen X. 2014. Effects of detection time-of-day on wintering water bird counts at the north bay of Erhai Lake, Yunnan. Chin J Ecol 33: 674-679.

Farley EB, Schummer ML, Leopold DJ, Coluccy JM, Tozer DC. 2022. Influence of water level management on vegetation and bird use of restored wetlands in the Montezuma Wetlands Complex. Wildlife Biol 2: e01016. DOI: 10.1002/wlb3.01016.

Ferguson-Lees J, Christie DA. 2001. Raptors of the World. Christopher-Helm, London.

Froneman A, Mangnall MJ, Little RM, Crowe TM. 2001. Waterbird assemblages and associated habitat characteristics of farm ponds in the Western Cape, South Africa. Biodivers Conserv 10: 251-270. DOI: 10.1023/A:1008904421948.

Gopal B. 2013. Future of wetlands in tropical and subtropical Asia, especially in the face of climate change. Aquat Sci 75: 39-61. DOI: 10.1007/s00027-011-0247-y.

Goudarzian P, Erfanifard SY. 2017. The efficiency of indices of richness, evenness and biodiversity in the investigation of species diversity changes (case study: migratory water birds of Parishan International Wetland, Fars Province, Iran). Biodivers Intl J 1: 41-45. DOI: 10.15406/bij.2017.01.00007.

Grundling RE, Turner DP, Grundling P, Beckedahl H, Haussmann NS. 2021. Accidental wetlands - a southern African case study from the Kgaswane Mountain Reserve, Rustenburg. S Afr Geograph J 103: 484-500. DOI: 10.1080/03736245.2020.1851294.

Hockey PAR, Dean WRJ, Ryan PG. 2005. Roberts - Birds of Southern Africa 7th edition. The Trustees of the John Voelcker Bird Book Fund, Cape Town, Africa.

International Union for the Conservation of Nature. 2022. IUCN Red List of Threatened Species. Version 2022.2. http://www.iucnredlist.org/.

Junk WJ, An S, Finlayson CM, Gopal B, Květ J, Mitchell SA, Mitsch WJ, Robarts RD. 2013. Current state of knowledge regarding the world's wetlands and their future under global climate change: a synthesis. Aquat Sci 75: 151-167. DOI: 10.1007/s00027-012-0278-z.

Kačergytė I, Arlt D, Berg Å, Zmihorski M, Knape J, Rosin ZM, Pärt T. 2021. Evaluating created wetlands for bird diversity and reproductive success. Biol Conserv 257: 109084. DOI: 10.1016/j.biocon.2021.109084.

Kruger AC, Mbatha S. 2021. Regional weather and climate of South Africa: Gauteng. South African Weather Service, Pretoria, South Africa.

Lee S-D, Kan H-K. 2019. Seasonal fluctuations and changing characteristics of a temperate zone wetland bird community. J Ecol Environ 43: 1-13. DOI: 10.1186/s41610-019-0108-5.

Magurran AE. 2021. Measuring biological diversity. Curr Biol 31: R1141-R1224. DOI: 10.1016/j.cub.2021.07.049.

Malekian M, Salarpour R, Ranaie M. 2022. Wetland characteristics affect abundance and diversity of wintering birds: a case study in south-western Iran. Ecol Evol 12: e9558. DOI: 10.1002/ece3.9558.

Mattos AE, Peris S. 2008. Influence of time of day, duration and number of counts in point count sampling of birds in an Atlantic Forest of Paraguay. Ornito Neotrop 19: 229-242.

Mitsch WJ, Hernandez E. 2013. Landscape and climate change threats to wetlands of North and Central America. Aquat Sci 75: 133-149. DOI: 10.1007/s00027-012-0262-7.

Mucina L, Rutherford MC, Powrie LW, van Niekerk A, van der Merwe JH. 2014. Vegetation Field Atlas of Continental South Africa, Lesotho and Swaziland. Strelitzia, South African National Biodiversity Institute, Pretoria.

O'Leske DL, Robel RJ, Kemp KE. 1997. Fall point counts: time of day affects numbers and species of birds counted. Trans Kansas Acad Sci 100: 94-100. DOI: 10.2307/3627996.

Reis V, Hermoso V, Hamilton SK, Ward D, Fluet-Chouinard E, Lehner B, Linke S. 2017. A global assessment of inland wetland conservation status. BioScience 67: 523-533. DOI: 10.1093/biosci/bix045.

Rollfinke BF, Yahner RH. 1990. Effects of time of day and season on winter bird counts. Condor 92: 215-219. DOI: 10.2307/3627996.

Ronchi-Virgolini AL, Lorenzón RE, Blake JG, Beltzer AH. 2013. Temporal variation of bird assemblages in a wetland: influence of spatial heterogeneity. Avian Biol Res 6: 198-206. DOI: 10.3184/175815513X13739097841679.

Roswell M, Dushoff J, Winfree R. 2021. A conceptual guide to measuring species diversity. Oikos 130: 321-338. DOI: 10.1111/oik.07202.

Saini V, Joshi K, Bhatt D, Singh A, Joshi R. 2017. Waterbird species distribution between natural and manmade wetland in Himalayan foothills of Uttarakhand, India. Biodiversitas 18: 334-340. DOI: 10.13057/biodiv/d180143.

Soendjoto MA, Riefani MK, Triwibowo D, Metasari D. 2018. Birds observed during the monitoring period of 2013-2017 in the revegetation area of ex-coal mining sites in South Kalimantan, Indonesia. Biodiversitas 19: 323-329. DOI: 10.13057/biodiv/d190144.

Subasinghe K, Sumanapala AP. 2014. Biological and functional diversity of bird communities in natural and human modified habitats in Northern Flank of Knuckles Mountain Forest Range, Sri Lanka. Biodiversitas 15: 200-205. DOI: 10.13057/biodiv/d150212.

Taylor MR, Peacock F, Wanless RM. 2015. The 2015 Eskom Red Data Book of Birds of South Africa, Lesotho and Swaziland. BirdLife South Africa, Johannesburg, South Africa.