Urban Ecosystems (2022) 25:1631–1641
https://doi.org/10.1007/s11252-022-01254-3

Human-wildlife interactions: presence of the ground-nesting Spotted Thick-knee across a South African mosaic urban landscape

Kyrone K. Josiah[1] · **Colleen T. Downs**[1]

Accepted: 2 June 2022 / Published online: 20 June 2022

Abstract
Urbanisation has increasingly encroached on numerous bird species' natural habitats, generally negatively affecting their persistence. Furthermore, increased human-wildlife interactions may benefit or be detrimental to the long term persistence of these species. The Spotted Thick-knee (*Burhinus capensis*), a ground-nesting species, persists in some mosaic urban landscapes in South Africa. We, therefore, assessed the presence of Spotted Thick-knees and their interactions with humans in the fragmented natural and human-modified landscape of Pietermaritzburg, KwaZulu-Natal. We conducted presence-only surveys at 52 locations between July 2019 and December 2020. 'Presence' locations for Spotted Thick-knee were identified via active surveying and public participation. Newspaper articles were distributed in June 2019, requesting information on Spotted Thick-knee sightings. Questionnaires were also sent to respondents to collect qualitative information regarding their perceptions and observations of this species in Pietermaritzburg. We established that the presence of Spotted Thick-knee's at known locations was not random. They were present at 30 out of 52 sites for 75% of this study's duration. Fewer sites had Spotted Thick-knees present during non-breeding months than breeding months. Respondents' feedback highlighted the pressures associated with Spotted Thick-knees persistence in human-modified mosaic landscapes, particularly predation and disturbance by domestic pets. Our study highlights that some ground-nesting birds, such as Spotted Thick-knees, persist in mosaic urban landscapes, despite the anthropogenic pressures. This study highlights the need to address the paucity of studies on ground-nesting birds in mosaic urban landscapes to determine general trends.

Keywords Spotted Thick-knee · Urbanisation · Questionnaire · Human-wildlife conflict · Resident population · Novel pressures

Introduction

Human global populations have increased significantly in the past 50 years. This has necessitated greater development and expansion of human settlements, especially in Africa (Tilman et al. 2017; da Silva and Gouveia 2020). With urbanisation spreading globally, cities typically require land and resources. This generally comes at the expense of the natural environment and its fauna and flora (Sol et al. 2014; Ibáñez-Álamo et al. 2017; da Silva and Gouveia 2020). Numerous studies have indicated that anthropogenic land-use changes, especially urbanisation, are a significant threat to biodiversity, particularly in the northern hemisphere (Cohen 2006; Aronson et al. 2014; Seress and Liker 2015; Ibáñez-Álamo et al. 2017; Litteral and Shochat 2017; Hersperger et al. 2018; Albert et al. 2020). However, other studies show that some of these altered landscapes generally have a mix of anthropogenic and natural elements creating mosaic urban landscapes that offer opportunities for the persistence of certain species (McCleery et al. 2012; Fournier et al. 2020; Spotswood et al. 2021; Downs et al. 2021). Some of these landscapes have natural or managed green spaces (e.g., parks, gardens, etc.) between built-up areas that provide suitable habitat, facilitate wildlife use, or act as ecological corridors for species persistence (McCleery et al. 2012; Widdows and Downs 2017; Downs et al. 2021). Some urban built areas still provide ecosystem functioning, but it is sometimes less complex than natural

✉ Colleen T. Downs
downs@ukzn.ac.za

Kyrone K. Josiah
kyronekentjosiah@gmail.com

[1] Centre for Functional Biodiversity, School of Life Sciences, University of KwaZulu-Natal, Private Bag X01, Scottsville, Pietermaritzburg 3209, South Africa

counterparts (Alberti 2005; Kowarik 2011; McCleery et al. 2012; Fournier et al. 2020).

Generally, animal species that persist with increased urbanisation exhibit behavioural plasticity, but typically mobility and body size are also key aspects that influence a species fitness in an urban area (Kark et al. 2007; Peterson et al. 2007; Lowry et al. 2013; Norton et al. 2016; Bradsworth et al. 2017; Rivkin et al. 2019; Fournier et al. 2020; Downs et al. 2021). Species that are more plastic in their diet and habitat selection are typically more tolerant of changes in environmental conditions. They have greater chances of persistence than species that are less tolerant and more specific in their diet and habitat (Peterson et al. 2007; Lowry et al. 2013; Norton et al. 2016; Bradsworth et al. 2017; Rivkin et al. 2019; Fournier et al. 2020), though there are exceptions (Downs et al. 2021). These species not only deal with their natural pressures such as predation or competition for resources but also conditions that escalate their natural pressures (e.g., decrease in suitable habitat or preferential resources resulting in increased competition) or newfound anthropogenic pressures such as harmful environments with urban pollutants or human-wildlife conflict (Bonnington et al. 2015; Soulsbury and White 2015; Goddard et al. 2017; Kekkonen 2017; Fournier et al. 2020).

Those avian species dependent on the land for a significant part of their reproductive life cycle are included in the reproductive behavioural group identified as "ground-nesting birds" (Somveille et al. 2019). The global number of identified species in an urban context has relatively few terrestrial bird species studied in this context. For example, a review of urbanisation and nest building in birds only mentioned one ground-nesting species (Reynolds et al. 2019), while two other urban avian guild studies only mentioned one ground-nesting species each (Fernandez-Juric 2000; Lim and Sodhi 2004). There is a need for studying ground-nesting birds with increased urban expansion that typically results in the decline of natural vegetation and natural land, which are two environmental factors they are highly dependent on for survival (Callaghan et al. 2019; Somveille et al. 2019).

Recently in some countries, including South Africa, there has been an increase in sightings of some ground-nesting bird species in urban areas, but generally, there is a paucity of knowledge of their urban ecology (BirdLife International 2021; SABAP2 2021; Josiah 2021). The Spotted Thick-knee (*Burhinus capensis*) is one such species that has a presence in South Africa's urban areas (SABAP2 2021; Josiah 2021). Spotted Thick-knees have been observed in or close to urban areas over the past 30 years, with reports of residential gardens and school grounds being used for nesting (BirdLife International 2021). Spotted Thick-knees are ground-nesting with the simplest form of nest construction, such as scrapes in the ground or eggs laid on bare ground; unable to perch on tree branches and similarly shaped objects because of their tridactyl foot structure; and rarely seen in the air but commonly sighted on the ground (Hockey 2005; Tarboton 2014; Hume et al. 2019). These traits emphasise their terrestrial dependence. They provide a suitable study model regarding their response to anthropogenic developments and land-use change in mosaic urban landscapes.

It has been increasingly important that studies should consider the public's observations and perceptions and obtain any information regarding negative and positive interactions with urban-dwelling species (Soulsbury and White 2015; Goddard et al. 2017; Downs et al. 2021). Information on human-wildlife interactions in urban areas is necessary for the conservation of bird species, especially those with greater terrestrial dependence for their survival, such as ground-nesting species and flightless species (Rico-Guevara et al. 2019; Tobajas et al. 2020). These species are likely more vulnerable in urban areas because they depend more on terrestrial surfaces for significant life cycle stages (e.g., nesting etc.).

Consequently, our study investigated Spotted Thick-knees' presence in an urban metropole, Pietermaritzburg, and assessed resulting human-wildlife interactions. We expected their presence to be erratic because of the different land uses and range of anthropogenic activities across the mosaic urban landscape of Pietermaritzburg. Furthermore, we expected that they generally are negatively affected by anthropogenic disturbances and pets. This study provides novel information about the species in an urban context.

Methods

Study species

The Spotted Thick-knee (Order: Charadriiformes; Family: Burhinidae) is a nocturnal bird species native to Africa. Of the two subspecies found in South Africa, *Burhinus c. capensis* is the only one found in the KwaZulu-Natal Province (Hume et al. 2019; SABAP2 2021). The species is categorised as "Least Concern" on the IUCN red list since 2016, but there needs to be an update to determine the current status of the species in terms of population numbers (BirdLife International 2016, 2021). Although classified as a shorebird, with distributions generally close to coastlines and aquatic environments, viable populations are located much further inland, even to the extent of occurring in relatively dry environments like savanna and desert biomes (Hockey 2005; Hume et al. 2019; SABAP2 2021). They are commonly observed whilst on the ground. Although they can fly well and are mostly a resident species, nomadic groups from resident populations have been identified (Hockey 2005). In South Africa, this ground-nesting species has a

known breeding period from August to April the following year (Hockey 2005; Tarboton 2014; Hume et al. 2019). The species' diet mostly consists of invertebrates, but they also consume small mammals and/or reptiles (Hockey 2005; Hume et al. 2019). More recently, this species has been observed in a range of anthropogenic land-use areas from rural farming lands to more anthropogenically influenced environments, such as highly developed residential suburbs and even areas where there is limited vegetation and greenery (Fig. 1) (BirdLife International 2016, 2021; Hume et al. 2019; pers. obs.).

Study area

Our study was conducted in KwaZulu-Natal Province, South Africa (Fig. 1). The focus area was the city of Pietermaritzburg (29°37′04″ S, 30°23′57″ E) and its peri-urban surroundings (within 15 km of the city perimeter). Pietermaritzburg is the capital city as well as the second-largest city in the KwaZulu-Natal Province, both in terms of geographic size (area = 126.2 km^2) and human population (~531,990 inhabitants as of 18 January 2021) (United Nations 2021).

Topographically, the city is situated in the Msunduzi River valley at the bottom of an escarpment (Bordy et al. 2017). The region generally experiences warm-to-hot summer temperatures with frequent rainfall and dry winters with high diurnal temperature variation (Nel 2009). The vegetation composition, topography and subtropical climate zone are the major factors that contribute to the area's suitability as a habitat for several wildlife species, particularly bird species (Singh and Downs 2016a, b; Thabethe and Downs 2018).

The city's zoning is a mix of old and new developments that have created a landscape mosaic of housing, industrial and business infrastructure, rural areas, and natural and managed green spaces (Singh and Downs 2016a, b). Housing ranges from informal settlements to residential suburbs consisting of properties with no gardens nor vegetation, properties with small gardens and limited vegetation, and properties in high-income suburbs with large garden spaces and various vegetation types. Industrial and business zones

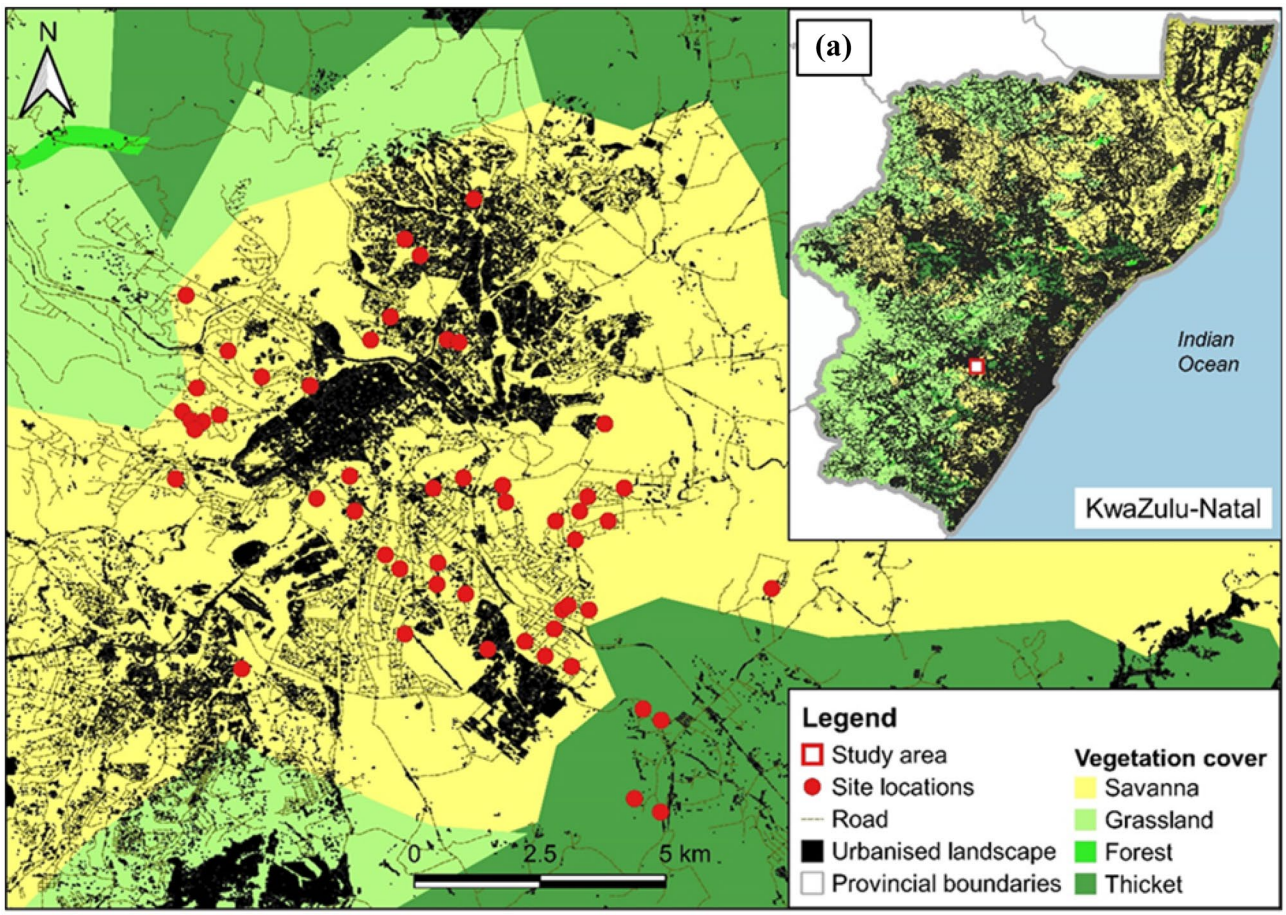

Fig. 1 Spotted Thick-knee site locations ($n = 52$) included in the present study across the mosaic urban landscape of Pietermaritzburg and (**a**) the study area in KwaZulu-Natal Province, South Africa

are generally vegetation-absent areas, although some places may have small gardens or a few trees. Pietermaritzburg has several natural and maintained green spaces, including areas of relatively large patches of natural vegetation and greenery, parks and gardens (e.g., the Hesketh Conservancy area) (Fig. 1). Some of these areas form potential natural or human-made greenbelts and/or ecological corridors for those species still present in and around the city (Fig. 1, pers. obs.).

Data collection- presence across the landscape

We identified Spotted Thick-knee locations in Pietermaritzburg using two methods in 2019 and 2020. Our first approach consisted of pilot observations carried out between 1 April 2019 and 30 June 2019 in public spaces and other accessible spaces across the city landscape at areas where the study species could have been found or sighted before the study commenced. The potential locations for the presence of individuals were based on existing literature and before-study observations of already identified locations of individuals/groups of the study species. The potential locations were first identified using Google Earth (Version 7.3.2), followed by actively surveying those identified areas to ground truth them and visiting any other areas of possible Spotted Thick-knee occurrence whilst carrying out field surveys. We conducted these surveys during the day between 08h00 and 17h00 when Spotted Thick-knees were least active in terms of movement. We did this until all publicly accessible areas of Pietermaritzburg were surveyed. The geographic locations of identified Spotted Thick-knees were recorded using a Global Positioning System (GPS, Garmin, USA). From this approach, 26 site locations were found by the start of the study field sampling on 18 July 2019.

Our second approach used public participation in the form of a newspaper article request for any geographic locations and/or information on Spotted Thick-knees' sightings by the public (Supplementary Material S1) (Singh and Downs 2016a, b). The article was distributed to the public in the first week of June 2019 in newspapers delivered throughout Pietermaritzburg and surrounding areas, often for free. There were 178 respondents to the article, but three gave sighting information for locations outside the study area so these three were excluded from data collection and analyses. Some participants gave multiple locations for Spotted Thick-knee sightings, and there were a few data points that were duplicated in terms of the general area where the Spotted Thick-knee were sighted. Through this approach, we identified 61 geographic locations of potential Spotted Thick-knee presence in the study area, but after ground-truthing locations and vetting reports of sightings from respondents, we excluded 20 geographic locations from further data collection and analyses. We excluded these locations in the study because they were locations where either Spotted Thick-knees had not been seen for more than 10 years; urban built development had occurred at a large scale, there was no natural landscape within 75 m radius of the site GPS location; private properties denied access when asked for permission; or sites with a false reporting with the respondent incorrectly identifying the bird species they sighted or the eggs when other ground-nesting species (e.g., Crowned Lapwing (*Vanellus coronatus*)).

We combined the 26 locations obtained using the first approach with 41 locations from the second approach, giving 52 locations because some sites were found through both approaches, resulting in duplications. We visited 47 sites from July 2019 to December 2020; while one site was visited from September 2019 to December 2020; two sites were visited from October 2019 to December 2020; one site from November 2019 to December 2020; and one site from January 2020 to December 2020. These latter five sites were not visited from the start because respondents contacted the study investigator after the commencement of field data collection. No field data collection took place during March–May 2020 because of South Africa's National Lockdown Regulations in response to the COVID-19 global pandemic. However, landowners typically shared information.

We visited sites at least once a month, but if the study species was not present during the first monthly visit, the site was revisited for a maximum of four further visits on temporally randomised days to get a recording for that specific month. If at least one Spotted Thick-knee was observed during a visit, the site location was recorded as 'present' for that month and recorded as 'not present' if there was no observed presence of the study species after five monthly visits. The duration spent at each site was a maximum of 15 min. If the study species was not found at the site at the end of the 15 min., it was recorded as 'not present' for that respective visit. The study species had mobility and was not expected to be at the exact same place as the original sighting. Therefore, a maximum radius distance of 75 m from the original GPS location (as the central reference point) where the species was first observed was used to determine whether the study species was still present in that relative location. 100 m was the maximum distance the observer could see and accurately identify the study species. However, in some cases, it was impossible to clearly see the surroundings at 100 m for a full 360˚ view because of obstruction of sight by obstacles such as buildings, walls and trees etc. Therefore, it was unavoidable that access was limited to an area less than a 75 m radius from the original GPS location for some sites on private properties. Sites within the same suburb or at a relatively close distance were visited on the same day to reduce the possibility that the same individuals were seen at different locations within the assumed movement range of the study species.

Public interactions and perceptions of the Spotted Thick-knee

A questionnaire (Supplementary Material S2) was distributed to members of the public or institutions that responded to the newspaper articles and requested geographic information on the study species. Ethical permission for the use of questionnaires for respondents was approved by the University of KwaZulu-Natal Humanities and Social Sciences Research Ethics Committee (Protocol number HSS-REC/00000865/2019) following the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration as revised in 2013. Of the 175 valid responders to the newspaper article, 144 completed and returned the questionnaire.

Data analyses

We analysed all data using IBM SPSS© Statistics version 27 (SPSS Inc., Chicago, USA). Non-parametric tests, in conjunction with descriptive statistics, were used because of the exploratory nature of the study and the sampling of count data. We used a Wald–Wolfowitz Runs test with the corresponding exact value to determine whether sightings at all visited locations over the study period were random or not. The binary cataloguing of the data with Spotted Thick-knee 'present = 1; absent/not present = 0' was suitable for such analyses. A user-defined value of '0.5' was set for the test because the use of the median, mean or maximum values would not be statistically appropriate for binary formatted data. This also allowed for the inclusion of locations that were reported in 2019 after the first month of field visits because the test results would not be compromised by locations where data were not collected over the full period of the study. Chi-square tests were used to compare the number of sites with presence/no presence for the same months but in different years to determine significant yearly changes.

We recorded the number of responses for each question as a percentage of all valid reports. Descriptive statistics were reported for novel trends or already-known aspects, which could be supplemented by existing literature. We highlighted the reporting of injuries or deaths of Spotted Thick-knee separately from other responses because most of them were recorded under "additional comments" or reported separately through e-mail or telephone calls. These reports were labelled as 'incidence(s)'. Some reported more than one incidence and/or incidences with different causes of injury or death to Spotted Thick-knees. A total of 216 incidences were reported, which were separated according to the cause of incidence. An incidence was grouped according to the known specific cause (domestic dog (*Canis lupus familiaris*), domestic cat (*Felis catus*), motor vehicle, pool drowning); general category of cause (wild animal); and unknown cause (including reports where the cause of injury or death was 'speculated').

Results

Presence across the landscape

Although the sampling method for site visits was randomised, the presence of Spotted Thick-knee at locations throughout the months included in the study was not random (Wald–Wolfowitz Runs test $z = -2.454$; $p = 0.016$). Of the sites, 7.9% ($n = 4$) had at least one Spotted Thick-knee present during all months of visit, 51.9% ($n = 27$) had the study species present during 75% to 99% of total months visited, 34.6% ($n = 18$) had the study species present during 50% to 74.9% of the total months visited and 5.8% of sites ($n = 3$) had the study species present during less than 50% of total months visited.

November 2019 had 92.0% of sites ($n = 46$) with the study species present, which was the highest for all months within the study period that had data collected. July 2019 had 55.3% of sites ($n = 26$) with the study species present, which was the lowest for all months within the study period that had data collected (Fig. 2). The four months with the lowest presence of Spotted Thick-knees were July 2019, February 2020, June 2020, and July 2020.

There was a significant difference in the number of sites with the presence of the study species in November 2019 ($n = 46$), which was greater than the number of sites with a presence in November 2020 ($n = 38$) ($\chi^2 = 6.28$; df = 1; $p < 0.012$). There was a significant difference between December 2019 ($n = 45$) which had a greater number of sites with the study species present compared with sites indicating presence in December 2020 ($n = 34$) ($\chi^2 = 7.53$; df = 1; $p < 0.05$). There were no other significant differences between the same months in different years.

Most sites where Spotted Thick-knees occurred across the mosaic urban landscape of Pietermaritzburg were in residential areas, specifically gardens ($n = 28$; 53.9%). The other sites were in recreational areas such as parks and school sports grounds ($n = 15$; 28.9%); greenspaces with natural vegetation in mixed-zone use that were not used as recreational areas ($n = 6$; 11.5%); in an industrial area, specifically a truck yard ($n = 2$; 3.8%); and in a conservation area ($n = 1$; 1.9%).

In some instances, we observed the movement of Spotted Thick-knee individuals in residential areas where we found them on private property in the initial month and the neighbouring private property in the following month. An individual or group in a residential garden was never observed to move to another open area in the site area. We made no observations of more than five Spotted Thick-knees at any

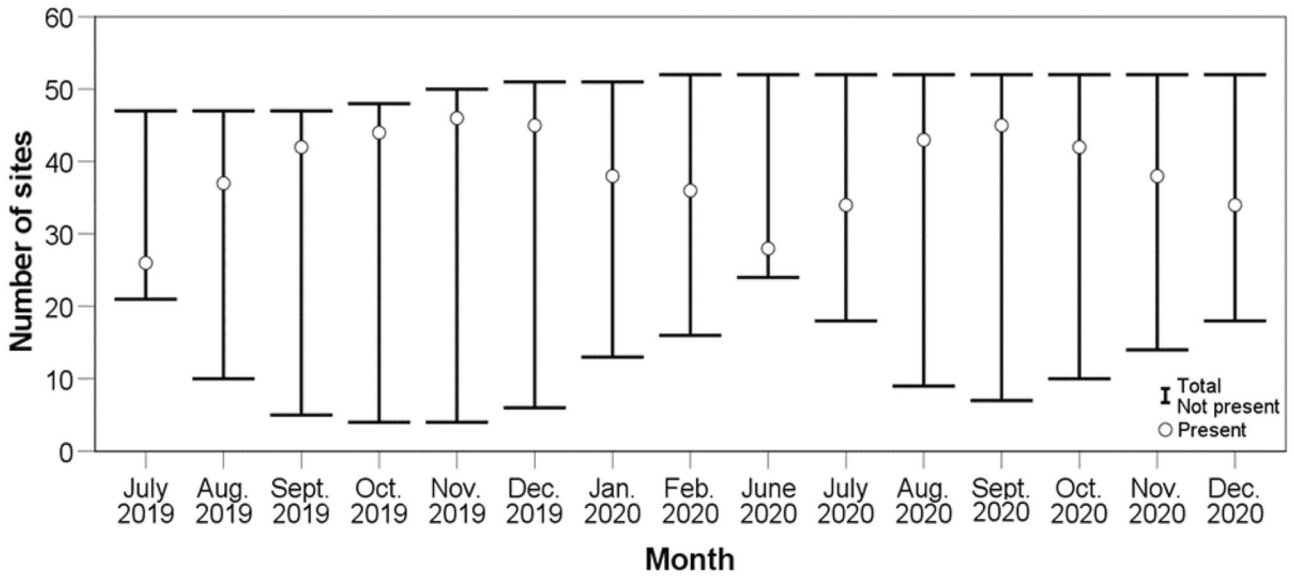

Fig. 2 Number of sites with Spotted Thick-knees 'present' or 'not present' in this study, relative to all site locations visited for each month. (The top-whisker indicates the total number of sites visited for each month; bottom-whisker indicates sites with study species not present, and the white dot (○) in the bar indicates sites with study species present)

one site during a single visit. Hatchlings and immature or sub-adult individuals were observed during the study (pers. obs.). However, not all sites had a pair of Spotted Thick-knee present, nor was there evidence of breeding and nesting behaviour at all sites where there were two Spotted Thick-knee for more than one month. At some sites, hatchlings and/or immature adults were not detected, nor a smaller number of them during further visits, although site visits were within a period where it was known that they would still be with the breeding pair.

Public interactions and perceptions of the Spotted Thick-knee

Most public participants ($n = 118$; 81.9%) had detected or observed Spotted Thick-knees in the afternoon (12h01–18h00). Spotted Thick-knees were most commonly seen in pairs ($n = 107$; 74.3%; Table 1). Spotted Thick-knees were most commonly observed standing or sitting still on the ground ($n = 125$; 86.8%; Table 1). They were most commonly observed in pairs and sometimes alone. They were rarely observed in family groups. This could be because the young are cryptic and generally hidden within taller grass or bush-area to prevent detection. Only two respondents observed them in groups of more than six members, with the largest group having 12 members.

Feeding by Spotted Thick-knees was observed, but the actual object consumed was rarely identified by respondents. Their feeding action was commonly described as the individual moving 'forward, pausing, pecking at the ground' and then repeating the process. For instances where it was difficult to tell what was consumed because of the object being incredibly small-sized, possibilities include small invertebrates and grass seeds (Hockey 2005; Hume et al. 2019).

Supplementary feeding attempts of Spotted Thick-knee were reported, although relatively rarely. Items offered and consumed included: cheese, rice, and shredded pieces of roast chicken (*Gallus gallus domesticus*) (pers. comm.). Some respondents reported that bowls of water were placed for the birds on extremely 'hot' days or they used to 'bath' and drink from the pool, water fountains or garden ponds) (pers. comm.). One respondent used to set up a water sprinkler which the birds would drink or 'bath' from (pers. comm.). Over time this led to the Spotted Thick-knee pair or family group waiting by the sprinkler on hot days (pers. comm.). Visual footage of this novel behaviour can be downloaded from or viewed at: https://drive.google.com/file/d/1GXQ4js0veiKmrd0PBZvTEHCq3V6xovs8/view.

Regarding conflict, public participants had mostly observed Spotted Thick-knee being threatened and predated ($n = 76$; 52.8%; Table 1). A total of 216 incidences were replorted regarding causes of injury or death to Spotted Thick-knees with 27.8% of reports domestic dogs ($n = 60$); 19.0% of pool drownings ($n = 41$); 17.6% of unknown causes ($n = 38$); 13.4% of wild animals ($n = 29$); 12.5% of domestic cats ($n = 27$); and 9.7% of motor vehicles ($n = 21$).

Swimming pool drownings were reported for Spotted Thick-knees, with most drowning incidents being

Table 1 Number of valid responses for each question from the total number of questionnaires ($n = 144$) completed and returned by public participants in the present study. (Frequency of responses is expressed as percentages)

Category	Number of valid responses	Frequency of responses as a percentage (%)
Detection		
Morning (06h01 – 12h00)	85	59. 3
Afternoon (12h01 – 18h00)	118	81.9
Evening (18h01 – 24h00)	36	25.0
Night-time (24h01 – 06h00)	20	13.9
Number of specimens (all-at-once)		
1 (Alone)	60	41.7
2 (Pair)	107	74.3
3–5	40	27.8
6–10	9	6.3
11 or more	2	1.4
Activity		
Feeding	29	20.1
Staying still	125	86.8
Nesting	65	45.1
Other: walking/running	97	67.4
Conflict		
Attack	26	18.1
Predated	76	52.8

hatchlings and juveniles (pers. comm.). Spotted Thick-knee adults and hatchlings were reported as casualties of road-kill incidents. Unknown injuries reported included hatchlings, sub-adults, and adults found dead or injured, but the cause was not mentioned by respondents. Relatively few instances of wild animal interactions with Spotted Thick-knees were observed, with vervet monkeys (*Chlorocebus pygerythrus*) being the most common species reported. Still, it was noted that in a few cases around the same neighbourhood, incomplete Spotted Thick-knee carcasses had been found. The area was known to be inhabited by a breeding pair of Spotted Eagle-Owl (*Bubo africanus*) (pers. comm.).

Many respondents highlighted the enjoyment Spotted Thick-knees gave them and how they appreciate and value the birds, especially in their gardens (pers. comm.). However, this appreciation was not the same for everyone. A few respondents mentioned that the bird is a food resource in some areas, although it is not consumed as frequently as before (pers. comm.). Three respondents expressed frustration towards Spotted Thick-knees because of their loud calls in the night or early morning hours before sunrise. A few respondents showed distaste or knew other members of the public who disliked the species to the point that they have shot and killed the individuals they have found in their gardens (pers. comm.). Others expressed caution towards the species and tried to chase them away from their properties, mentioning the species being 'bad luck'.

Discussion

We found that Spotted Thick-knee occurrence at study sites in the urban areas of Pietermaritzburg was not random and that most Spotted Thick-knees were present at sites for at least 75% of the months visited. Their limited movement is supported by existing literature for populations within this part of South Africa, where it has been suggested that they are mostly sedentary with a few individuals in a population that may be nomadic and that they rarely move around during the breeding season (Maclean 1993; Hockey 2005).

There were four months with the lowest presence of Spotted Thick-knees. It is no coincidence that June falls in the non-breeding season, July is the beginning of the breeding season, and February is the end of the breeding season. These periods are suggested to have greater movement of Spotted Thick-knees compared with months within the middle or 'peak' of the breeding season that takes place sometime between September and December within the same year (Tarboton 2014).

In some instances, we observed Spotted Thick-knee individuals in residential areas moved to the neighbouring private property in the following month. This was not unexpected as the species is mobile and capable of flight. We found that most Spotted Thick-knee were present at sites in residential areas such as residential gardens, and it is suggested that these areas have resources or provide some form of benefit to these individuals or groups. This was corroborated by

Josiah (2021) in a study of nesting Spotted Thick-knees in an urban landscape, showing that residential areas, specifically gardens, were preferred by breeding pairs and had a higher success rate of nesting compared with other land-use areas.

Although a group of 12 Spotted Thick-knees was observed by a public participant as mentioned in their submitted questionnaire, we made no observations of more than five Spotted Thick-knees at any site during a single visit. This is relatively common when breeding pairs separate from large flocks of up to 50 individuals as the breeding season approaches (Maclean 1993; Hockey 2005). Some pairs never had young present after breeding, suggesting a loss of fledglings for these individuals. This is not uncommon for precocial ground-nesting species as they experience the most risk to their survival within the first few months or first year of hatching (Brown and Downs 2003, 2004).

Spotted Thick-knees were most commonly seen or heard during the afternoon, followed by the morning period by respondents. Although they are more easily detected during the daytime, most respondents observed them sitting or standing still, typical of their inactivity period, spending more time on land with limited movements during the day (Hockey 2005; Hume et al. 2019). Supplementary feeding attempts of Spotted Thick-knee were reported, although relatively rarely. In contrast, this type of supplementary feeding was found to be common for African Woolly-necked storks (*Ciconia microscelis*) in suburban areas of KwaZulu-Natal (Thabethe and Downs 2018).

Respondents highlighted some of the conflicts and threats faced by Spotted Thick-knee persisting in urban areas. Spotted Thick-knees were reported to be aggressive, especially during the breeding season around nest sites, and were observed to spread their wings wide and screech loudly whilst moving towards the perceived threat or in a direction that would take the perceived threat's attention away from the nest as previously documented (Hockey 2005; Tarboton 2014; Hume et al. 2019). The most commonly observed threat to Spotted Thick-knees were domestic pets, specifically dogs. Respondents reported domestic cats were observed less as threats in reports of conflict, but this could be attributed to cats being crepuscular and sometimes showing peak activity at nighttime (Long et al. 2020). It is possible that many interaction events between Spotted Thick-knees and cats were not observed by respondents. This is supported by an additional comment from a respondent with the following statement: "In the morning I found the dead bird with scratches on the body, it looked like a cat attacked it as I heard its distress call followed by a cat screeching" (pers. obs.). Domestic cats and dogs are frequently mentioned as predation threats faced by wildlife in human-modified habitats (Long et al. 2020; Luna et al. 2021).

Urban persistence has allowed some species to limit predation from their natural predators because these areas may be inaccessible to such predators, which are generally much larger in size, making it difficult to inhabit urban areas (Manton et al. 2019). However, studies have shown an increased urban presence for some raptor species in South Africa (McPherson et al. 2021), such as the Verreaux's Eagle (*Aquila verreauxii*) (Symes and Kruger 2012); Peregrine Falcon (*Falco peregrinus*) (Altwegg et al. 2014); Black Sparrowhawk (*Accipiter melanoleucus*) (Rose et al. 2017); and Crowned Eagle (*Stephanoaetus coronatus*) (McPherson et al. 2019; Downs et al. 2021). The raptor species within the study area included natural predators of the Spotted Thick-knee such as the Verreaux's Eagle and Spotted Eagle-Owl, although their abundance and specific habitats are not fully known. Their presence suggests that some of the Spotted Thick-knee population in the study area are at risk from predation by unnatural and natural predators.

Many respondents enjoyed having Spotted Thick-knees in their garden. Bird species in gardens or green spaces in urban areas have been frequently mentioned as providers of calmness and joy to humans (Thabethe and Downs 2018; Methorst et al. 2020). However, this appreciation was not for everyone. A few respondents mentioned that Spotted Thick-knees are a food. Spotted Thick-knees were previously considered game birds (Maclean 1993), but this designation was recently removed (Hockey 2005; Hume et al. 2019). A few respondents disliked the species to the point that they have shot and killed the individuals they have found in their gardens (pers. comm.). Others were concerned the species' presence was a bad omen. This has been documented in Zulu culture, where Spotted Thick-knees are called 'umbangaqhwa', which means 'causer of frost' and their appearance at a location is associated with trouble (Msimang 1975). However, others say it is more their appearance when they lie low, with the white spots on their back looking like frost on a rock (Koopman et al. 2020). South Africa is a diverse country with inhabitants of various cultures and traditions. Therefore, it is important to gain insight into these social factors because they could prevent the species from occupying potentially suitable habitats.

Conclusions

From our study of the Spotted Thick-knee population across Pietermaritzburg's mosaic urban landscape, it was evident that the Spotted Thick-knee individuals/groups were a part of a resident population and their presence in select areas was not random. Spotted Thick-knees frequently inhabited human-modified habitats such as gardens. Public participation data and responses showed select areas provide suitable habitat for nesting and access to resources both natural and

unnatural (i.e., supplementary feeding). These areas may also provide relative safety from natural predators. However, the risks to Spotted Thick-knee survival in the gardens of urban dwellings were apparent, especially as prey to domestic pets. This study highlights the need to address the paucity of studies on ground-nesting birds in urban landscape mosaics to determine general trends.

Supplementary information The online version contains supplementary material available at https://doi.org/10.1007/s11252-022-01254-3.

Acknowledgements We are grateful to the members of the public who generously replied to our request for information on the geographic locations of the study species and /or who completed our questionnaire. Special thanks to K Moodley for assistance in the field and D Ehlers Smith for providing vital geospatial data for the map outputs. We thank FreeMe Wildlife Rehabilitation KZN for the contribution of valuable data and assistance in creating public awareness about the study. We thank the reviewers for their constructive comments that improved the manuscript.

Author contribution CTD and KJ conceptualised the research. CTD sought funding. KJ collected and analysed the data. KJ drafted the manuscript, and CTD provided comments and revisions to the manuscript.

Funding We thank the National Research Foundation (ZA, Grant 98404) and the University of KwaZulu-Natal (ZA) for funding.

Availability of data Data for this study are available on request from the authors but belong to the University of KwaZulu-Natal.

Code availability Not applicable.

Declarations

Ethics approval Approval of the ethical appropriacy of the research instrument was granted by the University of KwaZulu- Natal, Ethics committee (Protocol number HSSREC/00000865/2019).

Consent to participate All participants consented to participate in the questionnaire. No personal details were obtained.

Consent for publication Both authors consented to the publication.

Conflict of interest The authors declare no conflict of interest nor competing interests.

References

Albert CH, Herve M, Fader M, Bondeau A, Leriche A, Monnet AC, Cramer W (2020) What ecologists should know before using land use/cover change projections for biodiversity and ecosystem service assessments. Reg Environ Change 20:1–12. https://doi.org/10.1007/s10113-020-01675-w

Alberti M (2005) The effects of urban patterns on ecosystem function. Int Reg Sci Rev 28:168–192. https://doi.org/10.1177/0160017605275160

Altwegg R, Jenkins A, Abadi F (2014) Nestboxes and immigration drive the growth of an urban Peregrine Falcon *Falco peregrinus* population. Ibis 156:107–115. https://doi.org/10.1111/ibi.12125

Aronson MFJ, La Sorte FA, Nilon CH, Katti M, Goddard MA, Lepczyk CA, Warren PS, Williams NSG, Cilliers S, Clarkson B, Dobbs C, Dolan R, Hedblom M, Klotz S, Kooijmans JL, Kuhn I, MacGregor-Fors L, McDonnell M, Mortberg U, Pysek P, Siebert S, Sushinsky J, Werner P, Winter M (2014) A global analysis of the impacts of urbanisation on bird and plant diversity reveals key anthropogenic drivers. Proc R Soc B 281:1–8. https://doi.org/10.1098/rspb.2013.3330

BirdLife International (2016) *Burhinus capensis*. The IUCN Red List of Threatened Species 2016:e.T22693589A93414268. https://doi.org/10.2305/IUCN.UK.2016-3.RLTS.T22693589A93414268.en. Accessed 14 Jan 2021

BirdLife International (2021) Species distribution factsheet: *Burhinus capensis*. http://datazone.birdlife.org/species/factsheet/spotted-thick-knee-burhinus-capensis/distribution. Accessed on 14 Jan 2021

Bonnington C, Gaston KJ, Evans KL (2015) Ecological traps and behavioural adjustments of urban songbirds to fine-scale spatial variation in predator activity. Anim Conserv 16:529–538. https://doi.org/10.1111/acv.12206

Bordy E, Spclman S, Cole DI, Mthembi P (2017) Lithostratigraphy of the Pietermaritzburg formation (Ecca group, Karoo supergroup), South Africa. S Afr J Geol 120:293–302. https://doi.org/10.25131/gssajg.120.2.293

Bradsworth N, White JG, Isaac B, Cooke R (2017) Species distribution models derived from citizen science data predict the fine scale movements of owls in an urbanizing landscape. Biol Conserv 213:27–35. https://doi.org/10.1016/j.biocon.2017.06.039

Brown M, Downs CT (2003) The role of shading behavior in the thermoregulation of breeding Crowned Plovers (*Vanellus coronatus*). J Thermal Biol 28:51–58. https://doi.org/10.1016/s0306-4565(02)00036-0

Brown M, Downs CT (2004) Daily and seasonal differences in body and egg temperatures in free-ranging Crowned Lapwings (*Vanellus coronatus*). Afr Zool 39:115–122

Callaghan CT, Major RE, Wilshire JH, Martin JM, Kingsford RT, Cornwell WK (2019) Generalists are the most urban-tolerant of birds: a phylogenetically controlled analysis of ecological and life history traits using a novel continuous measure of bird responses to urbanization. Oikos 128:845–859. https://doi.org/10.1111/oik.06158

Cohen B (2006) Urbanisation in developing countries: Current trends, future projections, and key challenges for sustainability. Technol Soc 28:63–80. https://doi.org/10.1016/j.techsoc.2005.10.005

da Silva FJG, Gouveia RM (2020) Global Population Growth and Industrial Impact on the Environment. In: da Silva FJG, Gouveia RM (eds) Cleaner Production. Springer, Cham, pp 33–75. https://doi.org/10.1007/978-3-030-23165-1_3

Downs CT, Alexander J, Brown M, Chibesa M, Ehlers Smith Y, Gumede T, Hart L, Kalle R, Maphalala M, Maseko M, McPherson S, Ngcobo SP, Patterson L, Pillay K, Price C, Raji IA, Ramesh T, Schmidt W, Senoge ND, Shivambu C, Shivambu N, Singh N, Singh P, Streicher J, Thabethe V, Thatcher H, Widdows C, Wilson AL, Zungu MM, Ehlers Smith D (2021) Modification of the third phase in the framework for vertebrate species persistence in connected urban environments based on a review of case studies from KwaZulu-Natal Province. Ambio in press, South Africa

Fernandez-Juric E (2000) Avifaunal use of wooded streets in an urban landscape. Conserv Biol 14:513–521. https://doi.org/10.1046/j.1523-1739.2000.98600.x

Fournier B, Frey D, Moretti M (2020) The origin of urban communities: From the regional species pool to community assemblages in the city. J Biogeogr 47:615–629. https://doi.org/10.1111/jbi.13772

Goddard MA, Ikin K, Lerman SB (2017) Ecological and social factors determining the diversity of birds in residential yards and gardens. In: Murgui E, Hedblom M (eds) Ecology and Conservation of Birds in Urban Environments. Springer, Cham, pp 371–397. https://doi.org/10.1007/978-3-319-43314-1_18

Hersperger AM, Oliveira E, Pagliarin S, Palka G, Verburg P, Bolliger J, Grădinaru S (2018) Urban land-use change: the role of strategic spatial planning. Glob Environ Change 51:32–42. https://doi.org/10.1016/j.gloenvcha.2018.05.001

Hockey PAR (2005) Spotted Thick-knee, *Burhinus capensis*. In: Hockey PAR, Dean WRJ, Ryan PG (eds) Roberts Birds of Southern Africa, 7th ed. The Trustees of the John Voelcker Bird Book Fund, Cape Town, pp 387–388

Hume R, Kirwan GM, Boesman P (2019) Spotted Thick-knee (*Burhinus capensis*). In: del Hoyo J, Elliott A, Sargatal J, Christie DA, de Juana E (eds) Handbook of the Birds of the World, vol 3. Hoatzin to Auks. Lynx Edicions, Barcelona, pp 111–112

Ibáñez-Álamo JD, Rubio E, Benedetti Y, Morelli F (2017) Global loss of avian evolutionary uniqueness in urban areas. Glob Chang Biol 23:2990–2998. https://doi.org/10.1111/gcb.13567

Josiah KK (2021) Aspects of the urban ecology of the Spotted Thick-knee (*Burhinus capensis*). MSc Thesis, University of KwaZulu-Natal, Pietermaritzburg Campus

Kark S, Iwaniuk A, Schalimtzek A, Banker E (2007) Living in the city: can anyone become an urban exploiter? J Biogeogr 34:638–651. https://doi.org/10.1111/j.1365-2699.2006.01638.x

Kekkonen J (2017) Pollutants in urbanized areas: Direct and indirect effects on bird populations. In: Murgui E, Hedblom M (eds) Ecology and Conservation of Birds in Urban Environments. Springer, Cham, pp 227–250. https://doi.org/10.1007/978-3-319-43314-1_12

Koopman A, Porter R, Turner N (2020) Birds of KwaZulu-Natal and their Zulu names. John Voelcker Bird Book Fund, Cape Town

Kowarik I (2011) Novel urban ecosystems, biodiversity, and conservation. Environ Pollut 159:1974–1983. https://doi.org/10.1016/j.envpol.2011.02.022

Lim HC, Sodhi NS (2004) Responses of avian guilds to urbanization in a tropical city. Landsc Urban Plan 66:199–215. https://doi.org/10.1016/S0169-2046(03)00111-7

Litteral J, Shochat E (2017) The role of landscape-scale factors in shaping urban bird communities. In: Murgui E, Hedblom M (eds) Ecology and Conservation of Birds in Urban Environments. Springer, Cham, pp 135–159. https://doi.org/10.1007/978-3-319-43314-1_8

Long RB, Krumlauf K, Young AM (2020) Characterizing trends in human-wildlife conflicts in the American Midwest using wildlife rehabilitation records. PLoS One 15:e0238805. https://doi.org/10.1371/journal.pone.0238805

Lowry H, Lill A, Wong B (2013) Behavioural responses of wildlife to urban environments. Biol Rev 88:537–549. https://doi.org/10.1111/brv.12012

Luna Á, Romero-Vidal P, Arrondo E (2021) Predation and scavenging in the city: a review of spatio-temporal trends in research. Diversity 13:46. https://doi.org/10.3390/d13020046

Maclean GL (1993) Roberts' Birds of Southern Africa, 6th ed. Trustees of the John Voelcker Bird Book Fund, Cape Town, pp 258–259

Manton M, Angelstam P, Naumov V (2019) Effects of land use intensification on avian predator assemblages: a comparison of landscapes with different histories in Northern Europe. Diversity 11:70. https://doi.org/10.3390/d11050070

McCleery R, Moorman C, Wallace M, Drake D (2012) Managing Urban Environments for Wildlife. In: Silvy NJ (ed) The wildlife techniques manual: Management. John Hopkins University Press, Baltimore, pp 169–191

McPherson SC, Brown M, Downs CT (2019) Home range of a large forest eagle in a suburban landscape: Crowned Eagles (*Stephanoaetus coronatus*) in the Durban metropolitan green-space system, South Africa. J Raptor Res 53:180–188. https://doi.org/10.3356/JRR-17-83

McPherson S, Sumasgutner P, Downs CT (2021) South African raptors in urban landscapes: a review. Ostrich 92:41–57. https://doi.org/10.2989/00306525.2021.1900942

Methorst J, Arbieu U, Bonn A, Böhning-Gaese K, Müller T (2020) Non-material contributions of wildlife to human well-being: a systematic review. Environ Res Lett 15:093005. https://doi.org/10.1088/1748-9326/ab9927

Msimang CT (1975) Kusadliwa Ngoludala. Shuter & Shooter, Pietermaritzburg

Nel W (2009) Rainfall trends in the KwaZulu-Natal Drakensberg region of South Africa during the twentieth century. Int J Climatol 29:1634–1641. https://doi.org/10.1002/joc.1814

Norton BA, Evans KL, Warren PH (2016) Urban Biodiversity and landscape ecology: patterns, processes and planning. Curr Landscape Ecol Rep 1:178–192. https://doi.org/10.1007/s40823-016-0018-5

Peterson M, Peterson T, Liu J (2007) A household perspective for biodiversity conservation. J Wildl Manage 71:1243–1248. https://doi.org/10.2193/2006-207

Reynolds SJ, Ibáñez-Álamo JD, Sumasgutner P, Mainwaring MC (2019) Urbanisation and nest building in birds: a review of threats and opportunities. J Ornith 160:841–860. https://doi.org/10.1007/s10336-019-01657-8

Rico-Guevara A, Sustaita D, Gussekloo S, Olsen A, Bright J, Corbin C, Dudley R (2019) Feeding in birds: Thriving in terrestrial, aquatic, and aerial niches. In: Bels V, Whishaw IQ (eds) Feeding in Vertebrates: Evolution, Morphology, Behavior, Biomechanics. Springer, Cham, pp 643–693. https://doi.org/10.1007/978-3-030-13739-7_17

Rivkin LR, Santangelo JS, Alberti M et al (2019) A roadmap for urban evolutionary ecology. Evol Appl 12:384–398. https://doi.org/10.1111/eva.12734

Rose S, Sumasgutner P, Koeslag A, Amar A (2017) Does seasonal decline in breeding performance differ for an African raptor across an urbanization gradient? Front Ecol Evol 5:47. https://doi.org/10.3389/fevo.2017.00047. Accessed 15 Feb 2020

SABAP2 (2021) *Burhinus capensis*. Version 2021.2. http://sabap2.birdmap.africa/species/275. Accessed 14 Jan 2021

Seress G, Liker A (2015) Habitat urbanization and its effects on birds. Acta Zool Acad Sci Hung 61:373–408. https://doi.org/10.17109/AZH.61.4.373.2015

Singh P, Downs CT (2016a) Hadedas in the hood: hadeda ibis activity in suburban neighbourhoods of Pietermaritzburg, KwaZulu-Natal, South Africa. Urban Ecosyst 19:1283–1293. https://doi.org/10.1007/s11252-016-0540-6

Singh P, Downs CT (2016b) Hadeda Ibis (*Bostrychia hagedash*) urban nesting and roosting sites. Urban Ecosys 19:1295–1305. https://doi.org/10.1007/s11252-016-0541-5

Somveille M, Manica A, Rodrigues AS (2019) Where the wild birds go: explaining the differences in migratory destinations across terrestrial bird species. Ecography 42:225–236. https://doi.org/10.1111/ecog.03531

Spotswood EN, Beller EE, Grossinger R, Grenier JL, Heller NE (2021) The biological deserts fallacy: Cities in their landscapes contribute more than we think to regional biodiversity. Bioscience 71:148–160. https://doi.org/10.1093/biosci/biaa155

Sol D, Gonzalez-Lagos C, Moreira D, Maspons J, Lapiedra O (2014) Urbanization tolerance and the loss of avian diversity. Ecol Lett 17:942–950. https://doi.org/10.1111/ele.12297

Soulsbury CD, White PCL (2015) Human–wildlife interactions in urban areas: a review of conflicts, benefits and opportunities. Wildl Res 42:541–553. https://doi.org/10.1071/WR14229

Symes CT, Kruger TL (2012) The persistence of an apex avian predator, Verreaux's Eagle, *Aquila verreauxii*, in a rapidly urbanizing

environment. Afr J Wildl Res 42:45–53. https://doi.org/10.3957/056.042.0109

Tarboton WR (2014) Roberts Nests & Eggs of Southern African Birds: A Comprehensive Guide to the Nesting Habits of Over 720 Bird Species in Southern Africa. Trustees of the John Voelcker Bird Book Fund, Cape Town, p 102

Thabethe V, Downs CT (2018) Citizen science reveals widespread supplementary feeding of African woolly-necked storks in suburban areas of KwaZulu-Natal, South Africa. Urban Ecosyst 21:965–973. https://doi.org/10.1007/s11252-018-0774-6

Tilman D, Clark M, Williams D, Kimmel K, Polasky S, Packer C (2017) Future threats to biodiversity and pathways to their prevention. Nature 546:73–81. https://doi.org/10.1038/nature22900

Tobajas J, Descalzo E, Mateo R, Ferreras P (2020) Reducing nest predation of ground-nesting birds through conditioned food aversion. Biol Conserv 242:108405. https://doi.org/10.1016/j.biocon.2020.108405

United Nations (2021) World Urbanization Prospects: Pietermaritzburg Population 2021. United Nations population estimates and projections of major Urban Agglomerations. United Nations, Department of Economic and Social Affairs, Population Division. https://worldpopulationreview.com/world-cities/pietermaritzburg-population. Accessed 18 Jan 2021

Widdows CD, Downs CT (2017) Genets in the city: community observations and perceptions of large-spotted genets (*Genetta tigrina*) in an urban environment. Urban Ecosyst 21:357–367. https://doi.org/10.1007/s11252-017-0722-x