

Citizen science survey of non-native Rose-ringed Parakeets *Psittacula krameri* in the Durban metropole, KwaZulu-Natal, South Africa

Tinyiko C Shivambu^{1,2} , Ndivhuwo Shivambu^{1,2}  and Colleen T Downs^{1*} 

¹ Centre for Excellence in Invasion Biology, and Centre for Functional Biodiversity, School of Life Sciences, University of KwaZulu-Natal, Pietermaritzburg, South Africa

² Present address: Mammal Research Institute, Department of Zoology and Entomology, University of Pretoria, Pretoria, South Africa

* Correspondence: downs@ukzn.ac.za

The Rose-ringed Parakeet *Psittacula krameri* (Scopoli, 1769) has become invasive in several countries, including South Africa, mainly through the pet trade releases and escapees. We conducted an online questionnaire survey targeting the residents in Durban, eThekweni Municipality, KwaZulu-Natal, South Africa. We aimed to determine the distribution, habitat and diet of the Rose-ringed Parakeet. We also determined if the public perceived parakeets as pests and if control measures were supported. We found that many parakeet sightings were reported in Durban North, primarily in and around shopping centres. Approximately 64.5% of respondents provided feeding stations for parakeets, with most providing seeds and grains. A total of 173 (55.4%) respondents considered parakeets as a pest. Rose-ringed parakeets were reported to chase nine bird species, of which seven were native and two non-natives. Most respondents stated that parakeets should not be controlled. However, most of those who supported their control suggested shooting and destruction of eggs. We concluded that the distribution of parakeets is likely expanding and associated with anthropogenic activities in this urban landscape. However, public perceptions may make invasive Rose-ringed Parakeet management difficult.

Keywords: alien invasive species, public perceptions, questionnaire survey, supplementary feeding, urbanisation

Alien invasive species are regarded as a major threat to biodiversity, and they globally represent a significant impact on economies and human livelihoods (Lockwood et al. 2009; Sharp et al. 2011; Early et al. 2016; Luna et al. 2019). The significant threats associated with alien invasive species are typically limited by policy and management responses (Bax et al. 2003; Early et al. 2016; Moshobane et al. 2020). The management associated with alien invasive species are not only a social issue, but are increasingly becoming scientific and political (Verbrugge et al. 2013; Crowley et al. 2019; Luna et al. 2019). Hence public support may play an essential role in the management of these species (Bertolino and Genovesi 2003; Schüttler et al. 2011; Mentil et al. 2018; Pisanu et al. 2018; Crowley et al. 2019).

General public perceptions of the control of invasive species may be guided by the type of eradication method proposed for a particular species (Fraser 2006; Courchamp et al. 2017). In addition, social benefits, such as hunting for profit or medicinal use of the species, can positively influence public perceptions (Perrings et al. 2002; Pejchar and Mooney 2009). The control of invasive species can also be impaired by public objections (Sharp et al. 2011; Fischer et al. 2014). In particular, objections to the control

of charismatic species, such as the invasive Rose-ringed Parakeet *Psittacula krameri* (Scopoli, 1769), have been documented (Lambert et al. 2017; Luna et al. 2019).

The Rose-ringed Parakeet is one of the world's most invasive species, having established in approximately 35 countries as a result of the pet trade (Menchetti et al. 2016; Ivanova and Symes 2019; Strubbe and Matthysen 2020). It is also recognised as one of the species with increasing management related conflict issues, as a result of negative public perceptions of control measures (Carrete and Tella 2008; Luna et al. 2019). This is despite its negative impact on crops, biodiversity through competition with native species and as a vector for human and wildlife diseases (Ahmad et al. 2012; Strubbe and Matthysen 2009; Mentil et al. 2018; Pisanu et al. 2018).

The Rose-ringed Parakeet was first introduced to South Africa in the 1900s as part of the pet trade (Perrin and Cowgill 2005; Roche and Bedford-Shaw 2008; Hart and Downs 2014). This has resulted in accidental escapes and intentional releases of caged parakeets into the wild in Gauteng (Pretoria and Johannesburg), KwaZulu-Natal (Durban) and Western Cape (Cape Town) (Dean 2000; Roche and Bedford-Shaw 2008; Hart and Downs 2014; Symes 2014; Shivambu et al. 2021a). The estimated

population sizes of Rose-ringed Parakeets in Gauteng (Johannesburg) and KwaZulu-Natal (Durban) are 2 000 (Whittington-Jones 2017) and 1 783 (Shivambu et al. 2021a), respectively. However, there is a lack of information on its overall numbers and distribution in South Africa.

Our study aimed to determine the distribution, habitat and diet of Rose-ringed Parakeets. We also determined if the public perceived parakeets to be pests and if control measures were supported. We predicted that the public would provide bird feeders, as feeding birds is a well-known phenomenon, especially in urban landscapes (Galbraith et al. 2014; Tryjanowski et al. 2015; Galbraith et al. 2017). We also expected that the residents would not support the management of the Rose-ringed Parakeet, given that it is perceived to be a charismatic species (Hart and Downs 2014; Luna et al. 2019).

The study areas were selected based on Rose-ringed Parakeet observations from parallel studies in eThekweni Municipality, KwaZulu-Natal, South Africa (Shivambu et al. 2021a, b; Figure 1). The estimated human population size of this municipality is 1.34 million (eThekweni Municipality 2013; Zungu et al. 2019; Maseko et al. 2020). It has a unique dedicated network of green corridors, the Durban Metropolitan Open Space System (D'MOSS) (Roberts 1994; Zungu et al. 2019). These areas (i.e. parks, conservation sites, golf courses and nature reserves) are conserved for native flora, fauna and human outdoor activities (Roberts 1994; Zungu et al. 2019; Maseko et al. 2020). The urban landscapes are comprised of different vegetation structures (both native and non-native), of which some provide breeding, roosting and feeding sites for Rose-ringed Parakeets (Hart and Downs 2014; Shivambu et al. 2021a). The climatic conditions in the municipal area are warm and temperate, with an annual minimum average temperature of 17.3 °C and the maximum average temperature of 24.3 °C, and recorded yearly rainfall of approximately 830 mm (as of 2021–2022) (<http://en.climate-data.org/location/27097/>).

We developed an online-based questionnaire survey using Google forms (<https://www.google.com/forms/about/>). The questionnaire survey had a brief description of Rose-ringed Parakeets and the study aims, followed by 15 questions, of which many were closed-ended (Supplementary Material Table S1). The questionnaire was designed to collect information on Rose-ringed Parakeets' distribution, habitat and food types, and if respondents considered them to be pests and their perceptions of control measures (Table 1). The survey was active from 12 August 2018 until 10 July 2020 (699 days: 1 year ten months) to obtain an adequate number of responses.

The survey link (<https://forms.gle/52h21wKv7esZ34aQ8>) was distributed through Facebook, WhatsApp, local estate newsletters ($n = 3$), pet shops ($n = 32$) and printed letters ($n = 420$) targeting residents in eThekweni Municipality. Letters were distributed to the eco-estates managers and residents during sampling for parallel studies (Shivambu et al. 2021a, 2021b, 2022) and presentations. The ethical clearance to carry out this study was granted by the University of KwaZulu-Natal Humanities and Social Research Ethics Committee (number: HSS/0678/018D).

We performed all statistical analyses using R statistical software (version 3.6.1, R Core Team 2018). We plotted

the distribution of Rose-ringed Parakeet sightings using ArcGIS (version 10.4.1, ESRI 2018). We only calculated the descriptive and non-parametric statistics for the survey data, due to the nominal categorical nature of the data collected. We performed the chi-square test (χ^2) to determine if the number of respondents differed between the habitat types. We also used the chi-square test to determine the difference between the number of respondents who regarded Rose-ringed Parakeets as pests and those who did not. We further used the chi-square test to determine the difference between the number of respondents who supported the control for Rose-ringed Parakeets and those who did not.

A total of 312 participants completed the survey, with 93.5% ($n = 290$) having seen Rose-ringed Parakeets in different locations in the urban landscape. A total of 137 Rose-ringed Parakeets distribution sites were reported (Figure 1, Supplementary Material Table S2). A large number of Rose-ringed Parakeet sightings were in Durban North, particularly Umhlanga, followed by Durban central (Figure 1). We found a significant difference between the median number of respondents per habitat type (chi-square test: $\chi^2 = 29.82$; $df = 6$; $p = 0.004$). Most respondents had seen Rose-ringed Parakeets in and around shopping centres (38.5%; $n = 120$ participants), followed by suburbia (26.3%; $n = 82$) and golf courses (19.5%; $n = 61$) (Table 1, Figure 2 and 3). The majority of respondents had seen Rose-ringed Parakeets feeding (43.9%, $n = 137$), followed by nesting (26.3%, $n = 82$), flying around (16.0%, $n = 50$) and roosting (13.8%, $n = 43$) (Table 1).

Many respondents (64.5%; $n = 182$) provided supplementary feeding stations for Rose-ringed Parakeets at their residences (Table 1). Most respondents provided seeds (71.4%; $n = 130$) and grains (22%; $n = 40$) for parakeets (Table 1). There was no significant difference between the number of respondents who regarded Rose-ringed Parakeets as pests and those who did not regard them as pests (chi-square test: $\chi^2 = 19.27$; $df = 1$; $p = 0.162$). A total of 173 respondents (55.4%) did not consider Rose-ringed Parakeets to be pests, while 44.6% ($n = 139$) considered them to be pests (Table 1). The majority of participants (60.6%, $n = 189$) had seen Rose-ringed Parakeets chasing other bird species (Table 1). Respondents had observed seven native and two invasive bird species being chased by Rose-ringed Parakeets (Supplementary Material Table S3). Alien invasive species included the Common Myna *Acridotheres tristis* (Linnaeus, 1766) and the House Sparrow *Passer domesticus* (Linnaeus, 1758). The native species chased included the African Hoopoe *Upupa epops* subsp. *africana* Bechstein, 1811, Knysna Turaco *Tauraco corythaix* (Wagler, 1827), Red-winged Starling *Nyctognathus morio* (Linnaeus, 1766), Crested Barbet *Trachyphonus vaillantii* Ranzani, 1821, Golden-tailed Woodpecker *Campethera abingoni* (A. Smith, 1836), Black-collared Barbet *Lybius torquatus* (Dumont, 1805) and the Southern Black Flycatcher *Melaenornis pammelaina* (Stanley, 1814) (Supplementary Material Table S3). In addition, respondents indicated that parakeets chase woodpeckers and barbets from their nests during the breeding season (Figure 2; Supplementary Material Table S3). Some of the respondents indicated



Figure 1: A map showing where Rose-ringed Parakeets were observed by survey participants (grey squares) and roost sites (black stars) (from Shivambu et al. 2021a) in eThekweni Municipality (square in the inset map), KwaZulu-Natal, South Africa. The names and coordinates of the Rose-ringed Parakeet survey sites are provided in Supplementary Material Table S2.

Table 1: Summary information showing numbers of responses per question asked during the Rose-ringed Parakeet survey

Questions	Percentage (%) and number (<i>n</i>) of responses provided (in brackets) out of 312 participants	
	Answers	No answers
What best describes your dwelling?	100% (312)	0%
Townhouse	22.4% (70)	
Suburb	68.9% (215)	
Other	8.7% (27)	
Have you seen Rose-ringed Parakeets?	99.4% (310)	0.6% (2)
Yes	93.5% (290)	
No	6.5% (20)	
If yes, can you please specify the location	100% (312)	0%
Shopping centres	38.5% (120)	
Suburban residence	26.3% (82)	
Golf course	19.5% (61)	
Park	8.0% (25)	
Cemetery	2.9% (9)	
Townhouse	2.6% (8)	
School	2.2% (7)	
Do you feed them?	90.4% (282)	9.6% (30)
Yes	64.5% (182)	
No	35.5% (100)	
What do you feed them/it?	58.3% (182)	41.7% (130)
Seeds	71.4% (130)	
Grains	22% (40)	
Other	6.6% (12)	
Do you consider parakeets as pests?	100% (312)	0%
Yes	44.6% (139)	
No	55.4% (173)	
Do you see parakeets chasing other birds?	100% (312)	0%
Yes	60.6% (189)	
No	39.4% (123)	
Which birds did you use to see before parakeets were introduced in areas where you have seen them? Please list them.	47% (147)	0%
Golden-tailed Woodpecker <i>Campethera abingoni</i>	28.6% (42)	
Black-collared Barbet <i>Lybius torquatus</i>	37.4% (55)	
Crested Barbet <i>Trachyphonus vaillantii</i>	34.0% (50)	
Which activities were parakeets doing when you saw them?	100% (312)	0%
Feeding	43.9% (137)	
Nesting	26.3% (82)	
Roosting	13.8% (43)	
Flying around	16.0% (50)	
As alien species, do you think the number of parakeets should be controlled?	100% (312)	0%
Yes	42.3% (132)	
No	57.7% (180)	
If yes, explain how	42.3% (132)	57.7% (180)
Shooting	45.5% (60)	
Egg destruction	25.7% (34)	
Trapping	15.1% (20)	
Poisoning	7.6% (10)	
Fogging	6.1% (8)	

that they used to see Black-collared Barbet (37.4%, $n = 55$), Crested Barbet (34%, $n = 50$) and Golden-tailed Woodpecker (28.6%, $n = 42$) before the arrival of Rose-ringed Parakeets (Table 1).

The number of respondents who indicated that Rose-ringed Parakeets should be controlled was greater (57.7%, $n = 180$) than those who indicated that they should not be controlled (chi-square test: $\chi^2 = 16.72$; $df = 1$; $p = 0.001$) (Table 1). The majority of respondents who supported control suggested shooting (45.5%, $n = 60$),

followed by the destruction of eggs during the breeding season (25.7%, $n = 34$) (Table 1). When asked to provide additional information, respondents suggested that Common Mynas, House Crows *Corvus splendens* (Vieillot, 1817) and starlings should be controlled, instead of Rose-ringed Parakeets (Supplementary Material Table S3). In addition, some respondents noted that Rose-ringed Parakeets make noise and disturb golfers, with a few also stating that they did not know that they were non-native (Supplementary Material Table S3).

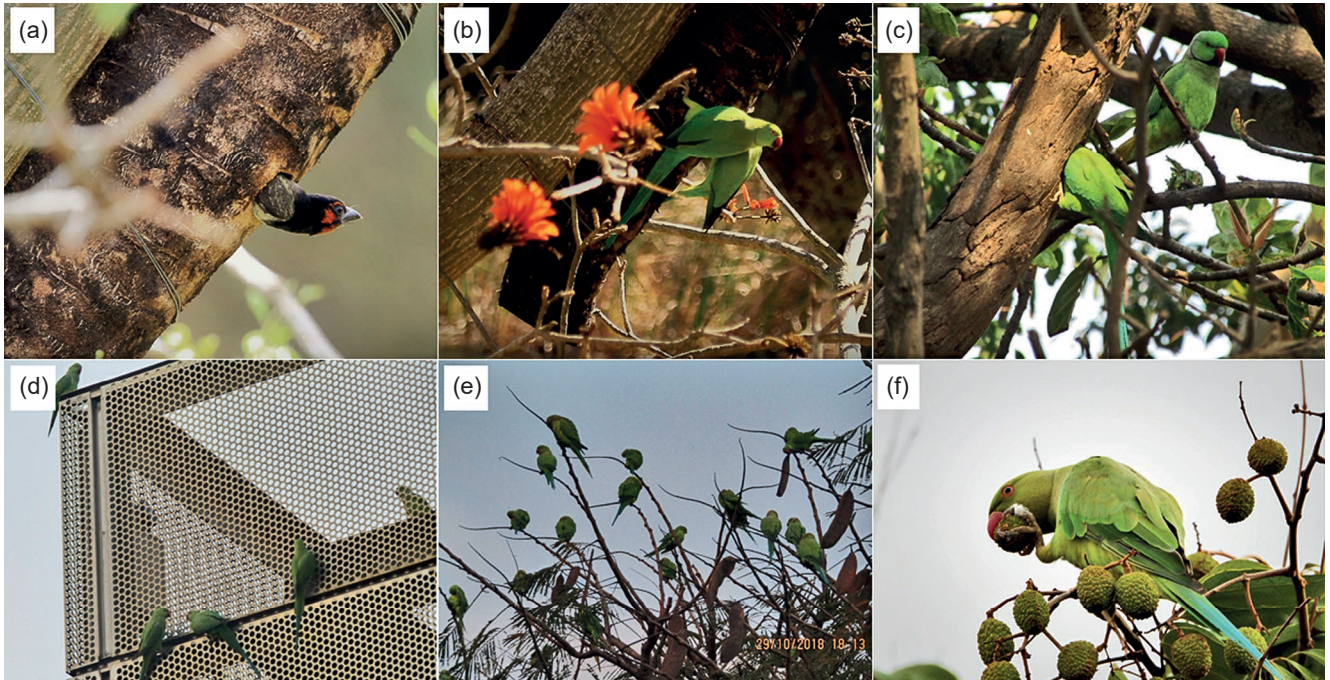


Figure 2: Photos of (a) a Black-collared Barbet *Lybius torquatus* leaving an artificial nest in a private garden in Mount Edgecombe Country Club, Durban North; (b) a pair of Rose-ringed Parakeets *Psittacula krameri* taking over an artificial nest placed for Black-collared Barbets in Mount Edgecombe; (c) male and female Rose-ringed Parakeets entering a natural nest excavated by native bird species in Merebank; (d) and (e) Rose-ringed Parakeet flocks in Gateway Mall, Umhlanga Rocks, and in a flat-crown tree *Albizia adianthifolia* in Cowey's Park Shopping Centre, Durban North; and (f) Rose-ringed Parakeets feeding on lychee fruits *Litchi chinensis* in a Mount Edgecombe garden. © Photographs (a–b) by M du Trevou, (c–e) by TC Shivambu, and (f) by G Frans)

Previous studies have underlined the possible complications and challenges associated with the management of charismatic alien invasive species, such as Rose-ringed Parakeets (Carrete and Tella 2008; Blackburn et al. 2010; Luna et al. 2019). It has been emphasised that studies of biological invasions are mainly impeded by public perceptions of charismatic species (Courchamp et al. 2017). This often results in the public's dislike of participating in studies on biological invasion, resulting in reduced participation in this study.

In our study, 93.5% of participants reported having seen Rose-ringed Parakeets in different locations and habitat types in the Durban metropole. The most Rose-ringed Parakeet sightings were reported in Durban North, particularly in Umhlanga. A previous study (Hart and Downs 2014) in this area reported fewer Rose-ringed Parakeet sightings than those observed in the present and a parallel study (Shivambu et al. 2021a; Figure 1). This showed that the population of Rose-ringed Parakeets is likely expanding in response to anthropogenic activities in the area, as reported in other countries (Czajka et al. 2011; Avery and Shiels 2017). Most of the locations reported in our study were around and within the confirmed roost and feeding sites (Shivambu et al. 2021a, b), indicating the reliability of citizen science data. Reported sightings away from roost sites could indicate unconfirmed roosts, especially sightings in the Bluff and Glenwood areas (Figure 1). This warrants further investigation to confirm the presence of other roost sites.

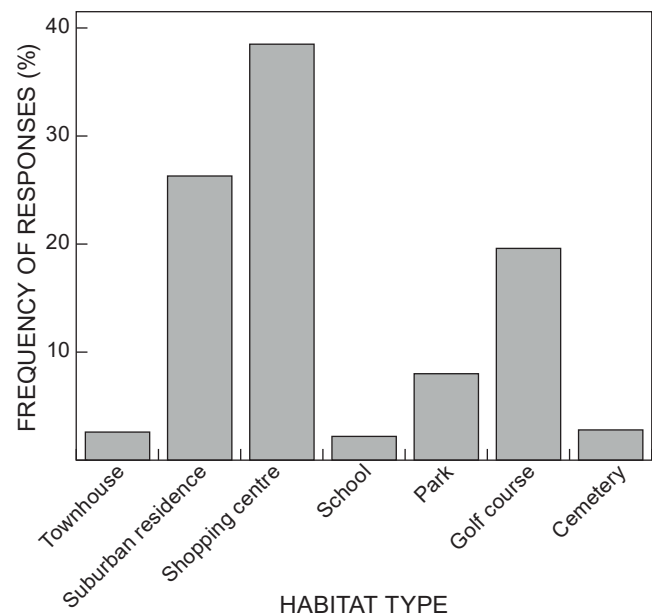


Figure 3: The percentage of survey respondents who reported sightings of Rose-ringed Parakeets in seven habitat types in the Durban metropole, KwaZulu-Natal, South Africa.

Many respondents had seen Rose-ringed Parakeets in and around shopping centres, followed by suburban residences and golf courses. The Rose-ringed Parakeets'

major roosts are in a shopping centre in Durban North and central Durban (Shivambu et al. 2021a; Figure 1), indicating that most respondents could have seen them visiting the shopping centre(s). Overall, our study indicated that Rose-ringed Parakeets are associated with urban landscapes with a relatively high human density. Typically, Rose-ringed Parakeets are pet escapees or releases and have evolved to live with humans (Roche and Bedford-Shaw 2008; Symes 2014; Strubbe and Matthysen 2020; Shivambu et al. 2021a, b). In addition, urban areas have a relatively high food availability for this species, especially in gardens and parks (Scalliet 1999; Wegener 2004; Strubbe and Matthysen 2007; Wolff and Touratier 2010; Shivambu et al. 2021b).

Our study revealed that many respondents provide supplementary feeding stations for Rose-ringed Parakeets, and the food types provided were mainly seeds and grains. This further supports Rose-ringed Parakeets' persistence and expansion in suburban areas of the Durban metropole. Rose-ringed Parakeets are mainly granivores; hence supplementary feeding stations with grains and seeds support their persistence in urban areas, as found in other studies (Sol et al. 2002; Clergeau and Vergnes 2011; Clergeau and Yésou 2006; Shivambu et al. 2021b). As a result, this species is likely to increase in numbers and become a pest with potential environmental and socio-economic impacts (Shivambu et al. 2020).

Most respondents did not consider Rose-ringed Parakeets as pests. This could indicate a knowledge gap about alien invasive species in the urban areas, and therefore introducing this topic to the public is necessary. Rose-ringed parakeets were reported chasing other bird species, of which the majority were native species. Although no fatal attacks were reported in our study, there might be impacts posed by Rose-ringed Parakeets, possibly through competition for nests. For example, respondents reported that Rose-ringed Parakeets chase woodpeckers and barbets out of the nests (Figure 2; Supplementary Material Table S3). In Seville (Spain), Tel Aviv (Israel), Barcelona (Spain), and Brussels (Belgium), Rose-ringed Parakeets are known to outcompete native species, such as the Great Tits *Parus major* (Linnaeus, 1758), Blue Tits *Cyanistes caeruleus* (Linnaeus, 1758), Nuthatches *Sitta europaea* (Linnaeus, 1758) and greater noctule bats *Nyctalus lasiopterus* (Schreber, 1780), for their food, nests and space (Strubbe and Matthysen 2009; Charter et al. 2016; Covas et al. 2017; Hernández-Brito et al. 2018).

Most respondents indicated that Rose-ringed Parakeets should not be controlled, with some suggesting rather controlling Common Mynas, House Crows and starlings. These results could be explained by the positive perceptions towards alien invasive species kept as pets and considered charismatic. Similarly, the Hart and Downs (2014) study in South Africa also indicated positive perceptions by the public towards Rose-ringed Parakeets compared with Common Mynas. Respondents who indicated that Rose-ringed Parakeets should be controlled suggested shooting and destroying eggs during the breeding season. In general, controlling Rose-ringed Parakeets would be difficult because many respondents oppose their control. In Seville (Spain), members of

the public objected to the management of Rose-ringed Parakeets, which has led to an increase in their population size, particularly in urban areas (Luna et al. 2019). In addition, some control programmes for charismatic alien invasive species have been unsuccessful in South Africa, e.g. the control of the invasive Mallard Duck *Anas platyrhynchos* (Linnaeus, 1758) in the city of Cape Town was opposed by the public (Gaertner et al. 2015). The objection of any control measures to reduce charismatic invasive species highlights the ecological knowledge gap for identifying the environmental and socio-economic impacts of such species (García-Llorente et al. 2008; Pett et al. 2016; Luna et al. 2019). As a result, the population of these species may increase and subsequently affect biodiversity, the economy and humans negatively.

This study showed that the distribution of Rose-ringed Parakeets is likely expanding in the Durban metropole given an increased number of observations (see Hart and Downs 2014; Shivambu et al. 2021a; SABAP2 2022). A high percentage of respondents provided feeding stations for Rose-ringed Parakeets, which may sustain their population in these areas. In addition, many respondents had positive perceptions of Rose-ringed Parakeets and did not support their control. Some of the respondents were not aware that parakeets were invasive species in South Africa. Therefore, we recommend that researchers, policymakers and municipality managers engage with the public to discuss the impacts associated with invasive Rose-ringed Parakeets and their management. This study's results can be used to understand social dilemmas in managing charismatic alien invasive species in urban landscapes.

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ORCIDiS

Tinyiko C Shivambu: <https://orcid.org/0000-0003-3157-4712>

Ndivhuwo Shivambu: <https://orcid.org/0000-0002-9336-9813>

Colleen T Downs: <http://orcid.org/0000-0001-8334-1510>

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