Assessing the success of red-billed oxpecker translocations as a conservation tool in KwaZulu-Natal, South Africa

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ABSTRACT

There are numerous factors that contribute to a bird species becoming threatened and in need of increased conservation efforts in order to survive. Compared with fossil records, current extinction rates are much higher than expected, which emphasizes the need for conservation. Conservation translocations aim to increase the survival of threatened species by ameliorating their possibility of extinction, and contribute either to educational, scientific or supportive purposes in this. Reintroductions or translocations are a well-established method for increasing a species' distribution and for restoring their historical range. Translocations are defined as human-mediated movements of organisms from one area and released in another. A translocation is only considered successful when a population is self-sustained through breeding of the released individuals and does not require intervention.

Oxpeckers are African passerines from the starling lineage. Historically, red-billed oxpeckers (*Buphagus erythrorhynchus*) had a distributional range that extended from Eritrea to Somalia, through south-eastern Sudan to Zimbabwe and into the former Transvaal, Natal and Eastern Cape Provinces, South Africa. Oxpecker populations became threatened in South Africa in the early years of the 20th century. In southern Africa, red-billed oxpeckers became *Near-Threatened* as a result of cattle dips with substances toxic to the birds, and because of a significant decrease in their large game host species. Conservation efforts in the 1980s onwards have attempted to deal with the factors causing their demise. In 2002, The Endangered Wildlife Trust began translocating red-billed oxpeckers to areas where they had gone locally extinct, in an attempt to increase their current distribution and population in South Africa. Consequently, we documented and reviewed the various capture and quarantine methods, conducted since 1988 to the present, in the various translocations of red-billed oxpeckers. We also highlighted lessons

learnt from these translocation events. To determine how successful these translocations were, we compared changes in the Southern African Bird Atlas Project (SABAP) reporting rate data and determined the presence or absence of red-billed oxpeckers at all the 24 translocation release sites in KwaZulu-Natal (KZN). In SABAP 1, data on species occurrences were collected at the Quarter Degree Grid Cell (QDGC) level. In SABAP 2, this was refined to pentads, where nine pentads are in one QDGC. Therefore, the reporting rate comparison was done at QDGC level. Prior to these translocations, red-billed oxpeckers were absent from all these sites. Specifically, we conducted transect surveys to determine red-billed oxpecker's population estimates in Ithala Game Reserve (IGR) and Tembe Elephant Park (TEP). We also netted and ringed red-billed oxpeckers at these sites to obtain morphological and genetic data and to determine their breeding status. Furthermore, we distributed an online questionnaire to determine public perceptions on red-billed oxpecker's range expansion in South Africa. We analysed the SABAP data using general linear modelling and the survey data using the Distance Programme in R Studio.

There was a significant increase in reporting rates of red-billed oxpeckers in southern Africa since the end of SABAP1 in 1991 with several new areas where they had established. This was again confirmed from landowners reporting the first observation made of red-billed oxpeckers on their respective properties. Reporting rates at the specific translocated release sites had also increased. Twenty-four per cent of the QDGCs (n = 170) showed an increase in reporting rates in southern Africa, however, 36% of the QDGCs showed a decrease in reporting rates (n = 258). Fourteen per cent of the QDGCs (n = 100) showed new areas colonized by red-billed oxpeckers. In South Africa, red-billed oxpeckers had colonised several new areas, particularly near areas where reporting rates had increased. Twenty-six per cent of the QDGCs showed areas where red-billed oxpeckers were absent and had gone locally extinct (n = 187); however these areas were mostly in Botswana and Zimbabwe.

We determined that habitat, host preference and host herd size were important factors when calculating population densities of red-billed oxpeckers. Detection probabilities for red-billed oxpeckers were highest in open bush habitat and where large herds were present. In IGR, red-billed oxpeckers were seen in 8% (n = 33) of the total of 391 observations made. In TEP, red-billed oxpeckers were observed in 6% (n = 24) of the total 378 observations made. In both IGR and TEP all red-billed oxpeckers we trapped and ringed had not been previously ringed and some had brood patches supporting their successful reproduction there.

To date, a total of 24 reintroduction events and 13 population reinforcements have taken place, with a total of 1359 red-billed oxpeckers translocated in South Africa. The increase in reports of red-billed oxpecker sightings, especially at release sites and on nearby land, showed the importance of translocations for the conservation of oxpeckers. In addition, the placement of artificial nest boxes has increased the likelihood of red-billed oxpeckers breeding at their new translocated site.

The recent down-grading of red-billed oxpeckers from *Near Threatened* to *Least Concern*, and the data collected in our study support the success of translocation as a conservation tool for this species. Translocations of red-billed oxpeckers in South Africa should be considered one of the more successful of such programmes as indicated by its success.

PREFACE

The data described in this thesis were collected in KwaZulu-Natal, Republic of South Africa from June 2015 to November 2016. Experimental work was carried out while registered at the School of Life Sciences, University of KwaZulu-Natal, Pietermaritzburg, under the supervision of Professor Colleen T. Downs, and co-supervision of Leigh Combrink.

This thesis, submitted for the degree of Master of Science in the College of Agriculture, Engineering and Science, University of KwaZulu-Natal, School of Life Sciences, Pietermaritzburg campus, represents original work by the author and has not otherwise been submitted in any form for any degree or diploma to any University. Where use has been made of the work of others, it is duly acknowledged in the text.

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Maryna Jordaan

December 2016

I certify that the above statement is correct and as the candidate's supervisor I have approved this thesis for submission.

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Professor Colleen T. Downs

Supervisor December 2016

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DECLARATION 1 - PLAGIARISM

I, Maryna Jordaan, declare that

1. The research reported in this thesis, except where otherwise indicated, is my original research.
2. This thesis has not been submitted for any degree or examination at any other university.
3. This thesis does not contain other persons' data, pictures, graphs or other information, unless specifically acknowledged as being sourced from other persons.
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    a. Their words have been re-written but the general information attributed to them has been referenced
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DECLARATION 2 - PUBLICATIONS

DETAILS OF CONTRIBUTION TO PUBLICATIONS that form part and/or include research presented in this thesis.

Publication 1

M. Jordaan, L. Combrink, & C.T. Downs

A history of translocations of red-billed oxpeckers in South Africa

Author contributions:

LC conceived this paper with MJ and CTD. LC collected information about the history of red-billed oxpecker translocations. MJ analysed the data, and wrote the paper. CTD and LC contributed valuable comments to the manuscript.

Publication 2

M. Jordaan, R. Kalle, P. Singh, L. Combrink & C.T. Downs

Assessing whether translocations were a successful conservation tool for red-billed oxpeckers in KwaZulu-Natal, South Africa

Author contributions:

MJ conceived the paper with CTD and LC. MJ collected and analysed data with the help from RK and PS, and wrote the paper. CTD and LC contributed valuable comments to the manuscript.

Signed:

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Maryna Jordaan December 2016

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Juvenile (left) and adult (right) red-billed oxpeckers trapped and photographed in Tembe Elephant Park, Durban, South Africa. Photos: Hennie and Marietjie Jordaan 2016.

CONTENTS

CHAPTER 1

Introduction

Translocation

Background

There are numerous factors that contribute to a bird species becoming threatened and in need of increased conservation efforts in order to survive (Soorae & Seddon 2000). One of the most common factors that threaten birds is habitat loss (Soorae & Seddon 2000). As the name suggests, it is the decrease in suitable habitat that birds may survive in (Soorae & Seddon 2000). This includes structures that make a bird's natural habitat unsafe, for example, power/utility lines and wind turbines that birds collide with (Burke & Rodwell 2000). Vultures, such as the bearded vulture (*Gypaetus barbatus*) are known to come into contact with these large structures (Frey & Walter 1989). Other factors are introduced birds that may outcompete native birds for feeding or nesting sites or introduced animals that may prey on native bird species (Soorae & Seddon 2000; Wanless *et al.* 2002). In New Zealand, there are numerous cases of birds that became threatened by the introduction of alien animals that predated on them (Parker 2013).

Diseases increase the likelihood of a species becoming extinct. With the increase in global temperatures, birds at lower altitudes have a higher risk of contracting and transmitting certain diseases (Zamora-Vilchis *et al.* 2012). Even factors such as being disturbed at breeding sites reduce the rate at which chicks are successfully raised. This had occurred with wattled cranes (*Bugeranus carunculatus*), which were unable to breed successfully due to disturbances (Burke & Rodwell 2000). Birds are often hunted for food, the illegal pet trade or for traditional medicinal practices (Hesse & Duffield 2000; Williams *et al.* 2014). Blue-and-yellow macaws (*Ara ararauna*) had gone extinct in Trinidad in the 1960's due to excessive harvesting for the pet trade, in addition to habitat loss (Plair *et al.* 2013). Across the African continent, vultures, hornbills and other large bird species are targeted more than other smaller species for trade in traditional medicine (Williams *et al.* 2014). Even if they are not targeted, birds are indirectly affected. For example, in South Africa birds of prey feed on poisoned carcasses that are aimed at killing mammalian predators that hunt the farmers' livestock (Anderson 2000).

Compared with fossil records, current extinction rates are much higher than expected, which emphasises the need for conservation (Barnosky *et al.* 2011). If other conservation techniques, such as habitat protection, law enforcement and education, have failed, only then should conservation translocations be considered (Scott & Carpenter 1987). Conservation translocations aim to increase the survival of threatened species by reducing their rate of extinction, either for educational, scientific or for supportive purposes (Cromarty & Alderson 2013). Translocations have been occurring for the past 100 years, however, re-introduction biology was only developed much later, when it became apparent that current translocation programmes were not succeeding (Kleiman 1989; Armstrong & Seddon 2007). The International Union for Conservation of Nature and Natural Resources Species Survival Commission (IUCN/SSC) Re-introduction Specialist Group (RSG) was developed in 1988 to study translocation attempts and how to improve the success rate (Armstrong & Seddon 2007). The RSG developed a set of guidelines to help translocation projects, which became an official IUCN policy in 1995 (IUCN 1998). These guidelines included definitions for re-introductions and translocations, which were later updated in 2013.

Translocations were first defined as "the deliberate and mediated movement of wild individuals to an existing population of conspecifics" (IUCN 1998). This later became: "Human-mediated movement of living organisms from one area, with release in another" (IUCN/SSC

2013). Human-mediated movements include accidental and intentional translocations. Accidental movements refer to invasive alien species, for example, the common myna (*Acridotheres tristis*) (Khoury & Alshamlih 2015). Conservation translocations are the "intentional movement and release of a living organism, where the primary objective is a conservation benefit: this will usually comprise improving the conservation status of the focal species locally or globally, and/or restoring natural ecosystem functions or processes" (IUCN/SSC 2013). Re-introductions were first referred to as "an attempt to establish a species in an area which was once part of its historical range but from which it has been extirpated or become extinct" (IUCN 1998). Later, this developed into population restoration, which is referred to as "any conservation translocation within the indigenous range" and it is made up of two activities (IUCN/SSC 2013). The first, reinforcement, refers to "the intentional movement and release of organisms into an existing population of conspecifics" (IUCN/SSC 2013). Secondly, re-introduction, refers to "the intentional movement and release of an organism inside its indigenous range from which it has disappeared" (IUCN/SSC 2013). Batson *et al*. (2015) developed a Translocation Tactics Classification System to enhance and support the IUCN guidelines, by providing a full list of tactics that can be used when planning a translocation event.

What is a successful translocation?

There are several benefits to translocating native species, for example, translocations assume that by releasing a species into a suitable habitat, it may be restored to its natural state (Seddon 1999). At the new site, translocated birds may increase the biodiversity, act as a keystone substitute of the ecosystem and/or create public support to restore and protect the habitat (Seddon 1999). Small populations of animals may increase, reducing inbreeding and increasing genetic diversity and establishing new populations (Scott & Carpenter 1987). However, factors that determine what a successful translocation is, are poorly understood (Linnell *et al.* 1997). A successful translocation must first be defined, before an intervention such as a translocation can take place (Kleiman 1989; Fischer & Lindenmayer 2000). There are several different definitions of what a successful translocation is. One states success as the breeding of the first wild-born generation, where fecundity is greater than mortality, with a three year breeding population that is established (Sarrazin & Barbault 1996). This includes a self-sustaining population that corresponds to a dynamic process, growth rate, growth rate variance and extinction probability estimates that are combined with population size (Sarrazin & Barbault 1996). Another defines success as a wild population of at least 500 individuals that does not need support (Olney *et al.* 1994). Alternatively, success may be simply defined as the establishment of a self-sustaining population (Griffith *et al.* 1989). An additional definition for success states that released individuals integrate socially with the resident population (Waples & Stagoll 1997). However, this can only be applied to reinforcement events, where founder populations are already present (Waples & Stagoll 1997).

Lastly, some consider a translocation successful when the population is self-sustained by the breeding of the released individuals and does not require intervention (Griffith *et al.* 1989; Dodd & Siegel 1991; IUCN 1998; Seddon 1999). This increases the persistence of a self-sustained population that has been assessed through extinction probability modelling (Griffith *et al.* 1989; Dodd & Siegel 1991; IUCN 1998; Seddon 1999). Extinction probability modelling may be considered the ultimate measure of whether a translocation was successful (Scott & Carpenter 1987). In order to measure this, the percentage of released birds that survived to breed successfully in the wild are determined (Scott & Carpenter 1987). However, because of the differences in life histories between species, these definitions are limited in addition to time (Seddon 1999). For example, if the project's aim was to have a self-sustaining population, it could then be deemed successful only at the time when the assessment was made (Seddon 1999).

Translocation events are on-going and require a large amount of effort. Therefore, by classifying a translocation event as successful, suggests an endpoint to which no further effort is needed (Seddon 1999). Self-sustainability does not mean the species will persist through time (Seddon 1999). New threats may arise in the translocated habitat, making the reintroduced species unable to sustain itself (Griffith *et al.* 1989; Seddon 1999). Some therefore consider success as a state, where long term monitoring continues.

Increasing the likelihood for success

There is a great need for modelling various scenarios and estimating survival rates of translocation events (Sarrazin & Barbault 1996). Translocations that first have experimental studies conducted, using statistical models, before release of captive bred individuals, increase the chances of a translocation being successful (Seddon *et al.* 2007). For example, statistical models that identify limiting factors can help plan for more successful translocations (Seddon *et al.* 2007). Limiting factors may include site of capture, body condition and presence of ectoparasites on the bird's body (Taylor & Jamieson 2007). Other models such as adaptive management models, help identify effective management techniques that can be applied to the reintroduction programme. As in the case of a New Zealand forest bird, the hihi (*Notiomystis cincta*), modelling illustrated the importance of supplemental feeding during the breeding season and control of parasites on the birds (Armstrong *et al.* 2007). Models can also be used to determine how source populations will react to being harvested for reintroduction purposes (Dimond & Armstrong 2007). Data collected from several sites, after a species reintroduction can be used to model more accurate population projections and predict future population trends (Parlato & Armstrong 2011). They can also be used, in addition to extinction probability modelling, to assess the success of a reintroduction, predict changes and identify factors that may affect mortality that would otherwise be obscured by ecological factors (Seddon 1999; Gerlach 2000).

In order to increase the likelihood of success, there are three factors that need to be considered (Reading & Clark 1996; Hunter 1998). The first is that the methodology of the reintroduction must take into account logistical and financial resources (Hunter 1998). Secondly, having open communication with and involving the local community (Hunter 1998). This includes maintaining a suitable habitat that is protected for the species that is to be translocated (Griffith *et al.* 1989; Wolf *et al.* 1998). Without a high quality habitat, that is maintained, translocations are less likely to succeed regardless of how many individuals are released (Griffith *et al.* 1989). Finally, the ecological requirements of the species that is to be translocated needs to be determined (Hunter 1998). In addition, statistical phylogenies have also determined that the range of a species' translocated area in relation to its historical distribution are correlated with successful translocations (Wolf *et al.* 1998).

It is important to consider the number of release events and the number of individuals per release, as it is correlated with a higher chance of translocation success (Griffith *et al.* 1989; Hopper & Roush 1993; Wolf *et al.* 1998; Deredec & Courchamp 2007). In most cases, the more individual birds that are released together are more successful than those that are released in small groups (Brightsmith *et al.* 2005). Smaller groups of birds that are released are more likely to be susceptible to stochastic events (Bradley *et al.* 2011). It is also essential that researchers take into account the effect of stress on translocated individuals (Richardson *et al.* 2015). There are factors that are presented as stressful situations to a translocated individual (Richardson *et al.* 2015). These include the lack of control, unpredictability, and novelty that is all associated with translocation events (Richardson *et al.* 2015).

In addition, researchers should identify the reason for population decline in the species that is to be translocated and state whether these issues have been successfully addressed at the new site where the species is being moved to. It is also important to report the cost of the translocation event. Translocation programmes are generally costly and as most translocated species are endangered, it is difficult to introduce species into unsuitable habitats (Scott & Carpenter 1987). It was shown that there was a positive correlation between the amount of money allocated for a species and their population trend (Luther *et al.* 2016).

Supportive measures that were taken should also be mentioned, these include: provision of shelter and food after the release, predator control and habitat modification, and special veterinary care (Fischer & Lindenmayer 2000). Veterinarian aid in the prevention of diseases, foreign or not, being developed in released individuals (Kock *et al.* 2007). Possible predators at the translocation site should be identified. Researchers need to define what they consider a successful translocation and state why they consider the translocation as successful or not. It is also important for all failures to be reported, and not only success (Griffith *et al.* 1989). It is important to publish reports on post-monitoring marked birds after their release (Scott & Carpenter 1987; Seddon 1999). This includes reporting translocation events of non-endangered birds (Scott & Carpenter 1987).

There are different release techniques that may be used, where the most common are hard or soft releases. Hard releases are defined as an individual's being released into a new environment, without extra aid after release, such as supplemental feeding or shelter (Richardson *et al.* 2015). Soft release, also known as a delayed release, is defined as individuals being kept at the release site in a holding pen for a period of time before being released (Richardson *et al.* 2015). This time in a field enclosure allows the bird time to acclimate to its new environment before being released (Mitchell *et al.* 2011). Supplementary food, shelter and other resources are also usually provided (Richardson *et al.* 2015). It is difficult to generalise as to which release technique should be used during a translocation event. This is because of the complexity and unique responses a bird may have to its new environment it has been translocated to (Batson *et al.* 2015).

Wild caught birds that are difficult to feed in captivity should be released as soon as possible when the capture and release sites are close together (Lovegrove 1996; Mitchell *et al.* 2011; Batson *et al.* 2015; Richardson *et al.* 2015). However, if sites are far apart, birds kept in aviaries until release need to become accustomed to artificial foods (Lovegrove 1996). Soft or delayed releases are best suited for birds that have been captive bred or that have been kept in captivity for an extended period of time (Lovegrove 1996). This time allows the birds to become accustomed to the wild and acquire necessary skills to survive in the wild (Lovegrove 1996; Richardson *et al.* 2015). Soft releases are also best used for birds that are likely to disperse or migrate (Lovegrove 1996). Translocations are not as successful on mainlands, as compared with islands, possibly due to higher dispersal rates on mainlands (Armstrong & Seddon 2007; Bradley *et al.* 2011). The time spent in the enclosure gives birds time to form pair bonds and connections with other birds in the same release group (Tweed *et al.* 2003; Mitchell *et al.* 2011). This has been shown to increase site-affinity and may increase the potential for successful breeding (Tweed *et al.* 2003; Mitchell *et al.* 2011). Ultimately, the success of re-introductions has not increased over time (Fischer & Lindenmayer 2000).

Study species

Species description

Oxpeckers are African passerine birds from the Sturnidae family (Zuccon *et al.* 2006; Lovette & Rubenstein 2007). Oxpeckers were considered starling-like birds, however, this classification was questioned, resulting in oxpeckers being classified in their own family, Buphagidae (Zuccon *et al.* 2006). However, a phylogenetic study showed that oxpeckers do belong in the Sturnidae family (Zuccon *et al.* 2006). Oxpeckers constitute the first, most basal branch within the Sturnidae family (Zuccon *et al.* 2006; Lovette & Rubenstein 2007). The red-billed oxpecker (*Buphagus erythrorhynchus*) can be identified by its red bill, yellow wattle around its eye and a dark rump (Craig 2005). Males and females are morphologically similar, whereas juveniles appear darker and lack a red bill and yellow eye ring (Craig 2005). They have been recorded in Eritrea, Somalia, south-eastern Sudan, Namibia, Angola, Botswana, Zimbabwe, Zambia, Mozambique and as far as Kenya (Bezuidenhout & Stutterheim 1980). In South Africa, they are most common in Limpopo, Gauteng and KwaZulu-Natal (KZN) Provinces (SABAP 2).

Breeding biology

Red-billed oxpeckers begin their breeding season in September and end in March (Craig 2005; Sinclair *et al.* 2011). These birds are regular cooperative breeders and they often live together in fixed groups at all times (Du Plessis *et al.* 1995; Craig 2005; Sinclair *et al.* 2011). Red-billed oxpeckers are secondary cavity nesters and they use grass, dung and mammal hair as nesting material (Craig 2005; Sinclair *et al.* 2011; Plantan *et al.* 2014). They often pluck hair and fur from ungulate hosts during the breeding season (Plantan *et al.* 2012). During a breeding experiment, oxpeckers plucked hair from hosts, and used them as platforms for breeding displays (Plantan *et al.* 2014). Therefore, we can assume that these hosts are essential to breeding success of oxpeckers (Stutterheim 1982). These birds show a great preference for savanna and woodland habitats (Du

Plessis *et al.* 1995). However, there is no clear indication as to what vegetation red-billed oxpeckers prefer, although they are absent in open grasslands and semi-desert Karoo flora (Stutterheim 1982). The absence is possibly due to the lack of trees to nest in (Stutterheim 1982).

Diet and relationship with hosts

Red-billed oxpeckers feed directly off skin parasites, such as ticks, in addition to earwax, skin parasites, insects, dead pieces of skin, hair, mucous excretions from the nose, eye and mouth (Bezuidenhout & Stutterheim 1980; Mundy 1983). They often search parts of the host's body that has soft tender skin, as these areas are favoured by ticks (D'Evelyn 1908). They run over animals searching for ticks, inspecting underneath, around the eyes and around the tail and anus, using their long stiffened tails to help stabilise themselves (D'Evelyn 1908; Sinclair *et al.* 2011). In South Africa, 53 stomachs of red-billed oxpeckers were analysed, showing that they predominantly ingested ticks from the genera *Boophilus* and *Rhipicephalus* (Bezuidenhout & Stutterheim 1980). More specifically, in a feeding trial, these birds preferred *B. decoloratus* and *R. appendiculatus* (Bezuidenhout & Stutterheim 1980).

Certain ungulate species are more preferred and regularly selected than other ungulate species as hosts by red-billed oxpeckers (Mooring & Mundy 1996). Several factors affect an oxpecker's choice of which ungulate host to feed on. These factors include the body mass and hair length of the animal, how the animal will react to the oxpecker foraging on it, habitat preferences of the hosts and lastly, the relative availability of host species in a given area (Grobler 1980; Hart *et al.* 1990; Dale 1992; Mooring & Mundy 1996; Mooring & Mundy 1996). Of all these factors, body mass may be the most significant factor to affect an oxpecker's decision (Hart *et al.* 1990). This is because the greater the body mass of an animal, generally the greater number of ticks their body is able to tolerate (Horak *et al.* 1983; Hart *et al.* 1990; Olubayo *et al.* 1993). Ultimately, oxpeckers will maximise their food intake and decrease their search time (Grobler 1980; Hart *et al.* 1990; Mooring & Mundy 1996; Mooring & Mundy 1996). Large herbivores, such as giraffe (*Giraffa camelopardalis*), zebra (*Equus quagga*), eland (*Taurotragus oryx*) and rhinoceros (*Ceratotherium simum*) are preferred as hosts of oxpeckers in Africa (Hart *et al.* 1990; Mooring & Mundy 1996; Mooring & Mundy 1996).

The relationship that oxpeckers have with ungulates was often characterised as mutualistic (Bronstein 1994; Bronstein 1994; Holland & DeAngelis 2001). This is because it was thought ungulate hosts benefit by having their tick load reduced and oxpeckers gain access to their main food source (Bezuidenhout & Stutterheim 1980; Mooring & Mundy 1996; Anderson *et al.* 1997). If the parasite load is not reduced, the host ungulate's fitness is compromised. For example, the animal's appetite is suppressed; there is increased blood loss and occurrence of skin, bacterial and protozoan diseases (Williams *et al.* 1978; Hart *et al.* 1990; Oorebeek & Kleindorfer 2008). In addition, possible benefits a host may receive from an oxpecker feeding on ticks may be indirect (Plantan *et al.* 2012). This is because oxpeckers generally feed on engorged ticks, which have already drained blood from the host and passed on any possible diseases to the host animal (Plantan *et al.* 2012). Therefore, the indirect benefit is that oxpeckers prevent tick reproduction (Plantan *et al.* 2012).

Interactions between ungulate hosts and red-billed oxpeckers have not always been shown to be mutualistic (Milius 2000). This is because oxpeckers do occasionally feed on blood directly from wounds, which does not benefit the host ungulate (Plantan *et al.* 2012). The costs the host experiences range from blood loss, flies that are attracted to the wound and old wounds that are reopened; all of which increases their chances of developing secondary infection (Samish 2000;

Weeks 2000; Plantan *et al.* 2012). The amount of time oxpeckers spend feeding from wounds depends on tick abundance and tick type (Plantan *et al.* 2012). Oxpeckers feed from wounds more often when less-preferred ticks are present; even when preferred ticks are present, wound-feeding incidences may still occur (Plantan *et al.* 2012). Also, if tick abundance is low, oxpeckers are likely to spend more time feeding from wounds, rather than searching for ticks on numerous hosts (Mooring & Mundy 1996; Mooring & Mundy 1996). The abundance, species and development stage of ticks preferred by oxpeckers also influence their feeding choices (Mooring & Mundy 1996; Mooring & Mundy 1996). Nevertheless, the relationship between oxpeckers and ungulate hosts is mutualistic and parasitic behaviours that do occur are opportunistic (Nunn *et al.* 2011). For the relationship to remain as beneficial for both bird and host, there needs to be a high abundance of tick types found on the host (Plantan *et al.* 2012).

Threats and conservation

Historically, red-billed oxpeckers had a distributional range that extended from Eritrea to Somalia, through South-eastern Sudan to Zimbabwe and into the former Transvaal, Natal and Eastern Cape Provinces, South Africa (Stutterheim 1982). Oxpecker populations became threatened in South Africa in the early years of the 20th century as a result of the culmination of: 1) the use of chemicals such as arsenic in cattle dips, 2) over-exploitation and hunting of wild game, 3) preferred wild herbivore hosts that were replaced with regularly dipped domestic stock, 4) the rinderpest epidemic from 1891-1897, and 5) a possible reduction in large trees that provide nesting cavities (Stutterheim 1982; Mundy 1983; Hall-Martin 1987; Anderson *et al.* 1997).

As early as 1890, it was accepted to use arsenic as an ingredient in cattle dips in the Eastern Cape (Stutterheim 1982). Arsenic trioxide can kill red-billed oxpeckers within 48h (Bezuidenhout

& Stutterheim 1980). Therefore, it is likely that the use of these chemicals led to local extinctions in South Africa (Stutterheim 1982). The decline in the oxpecker population in South Africa was not only because of the poisoning of the birds, but also from the lack of food resulting from the dipping practices. Furthermore, there are several reports where red-billed oxpecker populations declined until they were no longer seen, as a result of arsenic containing dips used on cattle farms (Stutterheim 1982). It is clear that the red-billed oxpecker's range was greatly reduced as a result of ingesting poisoned ticks and a decline in preferred host species (Stutterheim 1982). With the development of oxpecker friendly pyrethroid cattle dips were developed and oxpecker populations slowly recovered as a result (Plantan *et al.* 2014). However, their distribution was confined to game reserves, game farms, and areas with undipped cattle or the use of oxpecker friendly dips (Stutterheim 1982).

In 1996, a reinforcement took place west of Kimberley, increasing the number of birds in the area to an estimated ten individuals (Anderson *et al.* 1997). There were no reports published on whether the release of red-billed oxpeckers was successful or not (Anderson *et al.* 1997). In 1962, three red-billed oxpeckers were released into McIlwaine National Park, Southern Rhodesia, and in 1975, 12 red-billed oxpeckers were translocated to Rhodes Matopos National Park, Rhodesia (Davison 1963; Grobler 1979). After some post release monitoring, it was determined that both of these releases were unsuccessful as a result of the small amount of birds released (Davison 1963; Grobler 1979). In 2002, The Endangered Wildlife Trust (EWT) started an oxpecker capture and translocation programme, named Operation Oxpecker (Brooks 2008). The goal was to capture red-billed oxpeckers on cattle farms in northern Limpopo Province and translocate them to various farms and game reserves, where they had previously gone locally extinct in South Africa (Brooks 2008; Plantan *et al.* 2014). Translocations of oxpeckers began with a request from a farm or reserve in the former range for release of birds (Brooks 2008). An EWT official would visit the proposed site and surrounding areas to enquire about the management practices and the use of pesticides and ixodicides (Brooks 2008) (L. Combrink pers. comm.). Red-billed oxpeckers are caught in the non-breeding season and then translocated to the new location (Brooks 2008). To date, 1359 red-billed oxpeckers have been translocated under the Operation Oxpecker project (L. Combrink pers. comm.). Using these, a total of ten reintroduction events and ten population reinforcements have taken place.

Although red-billed oxpecker populations are increasing, they still need to be protected in South Africa (Plantan *et al.* 2014). By comparing South African Bird Atlas Project maps (SABAP 1 and SABAP 2), it is evident that they have expanded their range beyond the sites where they were released. However, no current accurate population estimates of red-billed oxpeckers are available for these release sites.

Study site

In South Africa, KZN Province is recognized as an internationally important area because of its diverse fauna and flora (Goodman 2003). Ecosystems in this province range from marine reefs, beaches and estuaries to grasslands, forests and semiarid savannah systems (Goodman 2003). Along with the diversity of ecosystems is a diversity of animals associated with the habitats (Goodman 2003). Ezemvelo KZN Wildlife is responsible for 110 protected areas, which are 7.72% of the land cover of the province (Goodman 2003). There were 25 sites in South Africa where red-billed oxpeckers were translocated to and released. We focused our research in KZN, where seven sites which received translocated red-billed oxpeckers were visited. Furthermore, we surveyed

Ithala Game reserve (IGR) and Tembe Elephant Park (TEP) to determine population estimates and genetic relatedness between individuals.

IGR (*27°30'57"S 31°19'53"E*) and TEP (*27°02'55"S 32°25'20"E*) are both located in northern KZN and they are both protected and governed by Ezemvelo KZN Wildlife. IGR was first proclaimed in 1972 and it is 29 653 ha (Johnson 1990). TEP was later proclaimed in 1983 and it is 30,012 ha (Matthews *et al.* 2001). Both these reserves had no red-billed oxpeckers present, prior to the translocation events in IGR (1994), when 98 red-billed oxpeckers were released, and in TEP (1997), when 103 red-billed oxpeckers were released. BirdLife South Africa (Africa 2015) had listed IGR as an Important Bird and Biodiversity Area (IBA).

Annual rainfall in IGR ranges from 500 to 1200 mm p.a., with an average of 791 mm p.a., where the majority falls in summer (Wiseman 2001). TEP experiences a larger range of rainfall, from 245 mm to 2105 mm p.a., however, on average the park receives 722 mm p.a. (Matthews *et al.* 2001). TEP's topography is relatively flat, interspersed with sand dunes that reach a height of 129 m asl with lowest areas at a height of 50 m. In contrast, IGR topography has altitudinal ranges from 350 to 1450 m asl (Johnson 1990). This results in a varied topography that changes from hilly grasslands, steep valleys, open woodlands to bushveld and savannah habitats (Johnson 1990). IGR has three main veld types in the reserve, and they are: Natal central bushveld, north eastern mountain grassland and Natal Lowveld bushveld (Johnson 1990). TEP has sand forests which are dominant, with grasslands bordering them, in addition to Muzi swamp, palmveld, and bushveld (Matthews *et al.* 2001). Summer temperatures range from 18 to 30^{o}C and winter temperatures range from 15 to 25^{o}C. On odd occasions, temperatures may reach 40^{o}C in summer and freezing point in winter (Johnson 1990). Temperatures in TEP range from a minimum of 9^{o}C to a high of 31.5^{o}C (Matthews *et al.* 2001).

Motivation and objectives of study

Until recently, red-billed oxpeckers were regarded as *Near-Threatened* (Craig 2005). However, in a recent assessment of the conservation status of red-billed oxpeckers, South African BirdLife has listed them as *Least Concern* (Taylor *et al.* 2015). This could partly be attributed to the various translocations of red-billed oxpeckers that have occurred before the start of Operation Oxpecker by the EWT and their current SABAP distributional range. However, there are no current population estimates for red-billed oxpeckers at their release sites. Through conservation efforts, there are several protected areas that have created suitable habitats for red-billed oxpeckers to be reintroduced and translocated to. There have been no follow up reports published on how the red-billed oxpeckers have survived after their translocations. This provides the opportunity to determine whether red-billed translocations have been successful.

The aim of this MSc project was to review the viability of translocations as a conservation tool for red-billed oxpeckers, particularly in KZN. We aimed to assess the success of past translocations of the red-billed oxpecker to KZN. We aimed to determine current population estimates, breeding occurrence, habitat use and range expansion from release sites. These will contribute to determining the success of the translocations to re-establish oxpeckers in KZN.

The main objectives of the project were to summarise past red-billed oxpecker capture techniques and translocation events, and in addition to conduct transect surveys in IGR and TEP. This would determine if red-billed oxpeckers were breeding in release sites in KZN and if the population estimates had increased from when oxpeckers were released. Host herbivores and land cover that would increase the likelihood of observing red-billed oxpeckers was also determined. This would ultimately determine whether the translocations that took place were successful or not.

If the translocated red-billed oxpeckers persisted for a minimum of one year and bred, we predicted that the translocation event was successful. However, continued presence and expansion at the release site will further support this as a useful conservation tool.

Thesis structure

The first chapter is an introductory review chapter followed by two data chapters which are prepared as manuscripts for submission to international peer-reviewed journals. The data chapters are as follows:

Chapter 2 describes the history of red-billed oxpecker translocations in South Africa. This includes the development of trapping techniques and release methods.

Chapter 3 determines the densities and abundances of red-billed oxpecker populations using line transects in two protected game reserves in KZN.

The thesis ends with a concluding chapter, Chapter 4, where the various findings in the data chapters are summarized and future research is discussed

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CHAPTER 2

A history of translocations of red-billed oxpeckers in South Africa

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Running header: Translocations of red-billed oxpeckers

Abstract

Reintroductions or translocations are a well-established method for increasing a species' distribution and for restoring their historical range. In southern Africa, red-billed oxpeckers (*Buphagus erythrorhynchus*) became *Near-Threatened* as a result of cattle dipping with substances toxic both to ticks and the birds, and because of a significant decrease in their large game host species. Consequently, as a conservation effort, birds were relocated within their historic range in an attempt to increase their current distribution in South Africa. We document the various capture and quarantine methods, summarise and review the releases, and highlight lessons learnt and benefits of these translocations. To determine how successful these translocations were, we compared changes in the Southern African Bird Atlas Project (SABAP) reporting rate data for areas around release sites and created a map to represent these changes. To date, a total of 24 reintroduction events and 13 population reinforcements have taken place, with 1359 red-billed oxpeckers translocated in South Africa. There was a significant increase in reporting rates of red-billed oxpeckers in South Africa. Translocations of red-billed oxpeckers in South Africa should be considered one of the more successful of such programmes.

Conservation implication: Red-billed oxpeckers were reported in several new areas. The increase in reports of red-billed oxpecker sightings, especially at release sites long after release, indicates the importance of translocations for the current range extension and conservation of oxpeckers.

Keywords: red-billed oxpecker, translocation, reintroduction, conservation, SABAP.

Introduction

Reintroductions and translocations have long been used as a tool for the recovery and conservation of many endangered species (Jachowski *et al.* 2011). This is particularly true in efforts to repopulate species in areas within their distribution range where they have become extirpated (Seddon *et al.* 2007; Teixeira *et al.* 2007). Reintroductions or translocations are a well-established method for increasing the numbers of species and restoring their historical distribution (Seddon *et al.* 2007). In the Unites States alone, Griffith *et al.* (1989) estimated that there were around 700 deliberate animal release programmes operating annually. Many of these translocation efforts end in failure (Jachowski *et al.* 2011). The main objectives of conservation translocation programmes are to ensure (1) the survival of the animals post-release, (2) the settlement of the animals into the release area, and (3) the successful reproduction of the released animals in their new environment (Teixeira *et al.* 2007). In addition, knowledge of the habitat that the animals will be released into, the number of animals, reproductive traits, programme length and the release location area in their former range are all important factors to consider to attain a successful release (Griffith *et al.* 1989). Furthermore, it is important for a project to define what it considers a successful translocation (Kleiman 1989; Fischer & Lindenmayer 2000). A translocation is generally considered successful when the population is self-sustaining, evidenced by the breeding of the released individuals and the perseverance of the population in the area (Dodd & Siegel 1991; IUCN 1998). Generally, translocations that involve threatened, endangered or sensitive species have a higher chance of failure (Jachowski *et al.* 2011).

Red-billed oxpeckers (*Buphagus erythrorhynchus*) were once found throughout the savanna biomes of South Africa, favouring the savanna and bushveld vegetation types (Feare & Craig 2001) where game was historically common. This species suffered significant declines throughout most of its global range (Feare & Craig 2001). In South Africa, this decline was primarily as a result of the over-exploitation and hunting of big game, a Rinderpest epidemic from 1891 to 1897, and the indiscriminate dipping of cattle with acaricides toxic to oxpeckers (Stutterheim 1982; Mundy 1983; Hall-Martin 1987). Oxpeckers were not lost solely as a result of the poisoning of the birds themselves, but also from the lack of available food resulting from dipping practices. Cattle dips containing acaricides are not necessarily fatal to the birds, but have been shown to decrease tick numbers substantially, so impacting the oxpeckers (Stutterheim & Stutterheim 1981).

With the development of new dipping compounds, toxic to ticks, but not to the birds (Plantan *et al.* 2014), the concept of re-establishing red-billed oxpeckers into areas within their historic range became a viable conservation option. In Zimbabwe, red-billed oxpeckers were completely eliminated from some areas (Feare & Craig 2001), but reintroductions of the birds occurred at the Matopos (Grobler 1979; Plantan 2009) and Lake McIlwaine National Parks (Davison 1963; Plantan 2009) to re-establish the species there. However, according to Mundy (1983; 1993), the species has not recolonized the Matopos National Park.

In South Africa, reintroductions of red-billed oxpeckers have been occurring for over 30 years. Initially, this process was run by the South Africa National Parks (SANParks) from 1988 - 1998. In 2002, the Operation Oxpecker Project was initiated by the Endangered Wildlife Trust to assume this role, with the aim of conserving existing populations of red-billed oxpeckers and expanding their range into areas where they occurred historically (Brooks 2008; Plantan *et al.* 2014).

Sutherland *et al.* (2010) suggested that standardization in reintroduction and post-release monitoring data collection and reporting methods are necessary in evaluating the success of individual programmes. Lack of standardization can lead to a deficiency in the information provided on reintroductions, making them impossible to evaluate objectively (Sutherland *et al.* 2010). Consequently, in this study, we document the methods used for capture and release of red-billed oxpeckers, summarise and assess their releases, and detail the lessons learnt and benefits of their reintroductions in South Africa. We also evaluate the effectiveness of these reintroductions as a conservation tool for this species.

Methods

Definitions

The IUCN guidelines for reintroductions and other conservation translocations (IUCN/SSC 2013) provide the following definitions with regards to the term conservation translocation and the difference between reintroductions and reinforcement: *Conservation translocation* is the intentional movement and release of a living organism where the primary objective is a conservation benefit: this will usually comprise improving the conservation status of the focal species locally or globally, and/or restoring natural ecosystem functions or processes (IUCN/SSC 2013). *Reintroduction* is the intentional movement and release of an organism inside its indigenous range from which it has disappeared (IUCN/SSC 2013). *Reinforcement* is the intentional movement and release of an organism into an existing population of conspecifics (IUCN/SSC 2013). By these definitions, and for the purposes of our study, any release of birds into an area within their historic range with a conservation benefit was considered a conservation translocation. If the release was into a "new" area where the species was not present, this was called an introduction. Any release into an area where the species was released previously or where there were birds already present, was considered a reinforcement.

Study species

Oxpeckers are African endemic passerines from the Sturnidae/Buphaginae family (Zuccon *et al.* 2006; Lovette & Rubenstein 2007). The red-billed oxpecker can be identified by its red bill, distinctive yellow wattle around its eye and a dark rump (Craig 2005). Males and females are morphologically similar, whereas juveniles appear darker, and lack a red bill and yellow eye ring (Sinclair *et al.* 2011). These birds feed primarily on ticks, dead skin and bodily fluids such as blood, saliva, sweat and tears, which are found on large ungulate hosts (Weeks 2000). Bezuidenhout and Stutterheim (1980) examined the stomachs of 53 red-billed oxpeckers caught in the Kruger National Park (KNP) and found a range of between 16 and 1665 ticks per stomach. In captivity, a single red-billed oxpecker was found to consume the equivalent of 7195 engorged *Amblyomma hebraeum* nymphs (Bezuidenhout & Stutterheim 1980). This tick-control service is especially beneficial for landowners with wild game, where dipping is not possible. These animals can act as "tick reservoirs" over which the farmer has no control and subsequent re-infestation of cattle by ticks after dipping occurs at a much faster rate where untreated game is present (Hunter-Oberem 2011).

Capture Process

Red-billed oxpeckers are co-operative breeders, with groups comprising an alpha pair and usually three to four helper birds (Craig 2005). The breeding season is from October until March each year (Craig 2005). Oxpeckers drink regularly and during the dry season when natural water sources are dry, they frequent windmills and reservoirs for water. This method was used in the KNP during the period 1988-1998. During the wet season, when water is readily available, catching oxpeckers near water sources was difficult with relatively poor success. For the later captures in the KNP, oxpeckers were caught where they congregated around the animal holding bomas at Skukuza, KNP. For captures that occurred outside of the KNP, oxpeckers were caught on cattle farms where they visited livestock that were concentrated and coralled. Captures only took place during the non-breeding season, which coincided with the dry season in savanna and bushveld regions. Artificial nest poles were provided placed at release sites for translocated red-billed oxpeckers. Nest pole length ranged from 1.5 to 2.5 meters with a width of ~15 cm. A hole was drilled into the top of the pole to a depth of ~55 cm with a width of 10 – 12 cm.

Captures 1988-1998

Methods utilising water points

Observations at water points and reservoirs prior to capture attempts was found to be critical for learning the red-billed oxpeckers' flight patterns prior to attempting captures. Typically, the oxpeckers perched on one of the highest points in the vicinity providing them with an overall view of the surrounding landscape and water point, possibly to assess threats to their safety before flying down to the water. Some captures occurred at water troughs, when water reservoirs were not available in the capture area. Once the oxpeckers' flight path to the water was established, mist-nets were erected between the perch and drinking point. At water points where the water reservoir was used, mist-nets were positioned with the bottom string of the net just below the top of the wall, almost touching it. At sites where drinking troughs were used, mist-nets were set parallel to the trough and about one metre from it with the bottom string at ground level. Mist-nets set at water reservoirs were more selective with only oxpeckers being caught. Mist-nets at the water troughs caught many non-target species which were released.

Methods utilising animals

An alternative method to catch red-billed oxpeckers was where a donkey was tethered at the edge of the water of a small dam (N'wanetsana), with mist-nets being erected between the favoured perch and the donkey. When an animal is present near the water when oxpeckers come to drink, they generally fly on to the animal before flying down to drink (pers. obs.).

The use of a noose blanket to trap oxpeckers, where nooses (made of light nylon fishing line) were sewn onto a dark coloured blanket that was then placed onto a donkey, was also tested as a possible capture method in the KNP. When oxpeckers foraged on the blanket-covered animal, their legs were caught up in the nylon nooses. This method was successful in recapturing some escaped birds during the captures in the KNP (1988-1998). This method was however, not tested thoroughly and should be considered as a possible additional technique, especially at sites where the oxpeckers are familiar with mist-nets and so avoid them.

Captures 2002-2014

Captures utilising bomas and waterholes

Captures of red-billed oxpeckers that occurred within the KNP during this time were conducted at the Skukuza veterinary bomas, and at select waterholes and pans. At the veterinary bomas, mist-nets were placed around select bomas where host animals were housed. Oxpeckers were captured when flying down to feed on the animals. Captures also took place on privately owned cattle and game farms. In these cases, cattle were coralled and mist-nets were placed around the coralled animals. The success of capturing oxpeckers at any site deceased drastically two-three days after the initial capture attempt and we found greater success in moving from an area after two days of capture. The initial area was often revisited after at least a two-day break for further oxpecker capture attempts.

Utilising decoys

In 2014, during one of the oxpecker capture attempts, the Operation Oxpecker Project borrowed a replica fibreglass rhinoceros (*Ceratotherium simum*) from SANParks to use as a lure for oxpeckers. It was placed at the Skukuza animal bomas with mist-nets surrounding it and initially was found to be quite a successful method of capture. Subsequent attempts, however, have had varying results. In some cases, this limited success was attributed to the weather. Wind, in particular, made mist-nets visible to oxpeckers, diminishing chances of successful capture. In addition, extreme heat conditions decreased oxpeckers' activity and they preferred to perch on an animal in the shade as opposed to fly around searching for foraging opportunities. The use of the decoy surrounded by mist-nets at waterholes and pans was more successful. This method was also highly selective for oxpeckers with minimal by-catch of other bird species.

Marking and ringing

Captured red-billed oxpeckers were removed from the mist-nets and generally held in temporary sock-like keep nets before measuring and ringing. These were made of wire/plastic hoops covered with shade cloth/netting to form cylinders about 1.5 m high and 0.5 m in diameter. Drawstrings were placed at the top and bottom ends of the net for sealing when holding birds. Oxpeckers were ringed on the right leg using standard numbered rings/bands (size 4.3 – 4.5 mm) supplied by AFring (Cape Town). Coloured rings were fitted to the left leg to indicate capture site location, with all oxpeckers captured at the same site fitted with the same ring colour. Different colours were used for different years although birds were captured at the same site. Standard measurements were taken, including: wing length, tail length, tarsus length, culmen length and mass. Age class was determined according to bill colour. Oxpeckers with any black in the bill were classed as sub-adults, while those with pure red bills were classed as adults. Juvenile oxpeckers were identified by distinct bills that are completely brown and they have not yet developed the characteristic yellow eye wattles of the adults (Craig 2005). As sex cannot be determined visually, wing length was used where possible, with males generally having longer wings than females (Craig 2005). In captures occurring post-2002, drops of blood were collected from the brachial vein of each bird, using an insulin (0.3mm/ 30 G) needle and blotting paper. Blood drop samples were collected and sent to a commercial laboratory for sex determination of each individual and for later DNA analyses.

Housing and quarantine

For birds captured within KNP, which is situated within the red line for Foot-and-Mouth disease zone, they were quarantined for a minimum of one week. Captured red-billed oxpeckers were housed in specially designed aviaries (3 m x 6 m x 2.5 m). In some cases, these were modified to allow for donkeys to be placed into the bomas, to assist with acclimatising the birds to captivity. Where donkeys were present, the artificial food was placed on the animals which enabled the birds to locate it easily and identify it as food. Donkeys were not used for any of the 2002-2014 captures. Food and water were placed in metal or plastic trays, with two sources of each provided for the birds to eliminate dominance at any one source.

Oxpeckers spend a considerable amount of time sunning themselves in the early morning (pers. obs.). Consequently, it was essential that adequate heating was provided for the oxpeckers in a captive environment, either through the use of oil heaters or heat lamps. At least two sources of each were provided to account for possible dominance of any one heat source by some birds. The timing of captures was also planned for the warmer months (August and September), to avoid any fatalities as a result of the cold.

Diet in captivity

Although there were a number of modifications during the various capture events, the main ingredients in the supplementary food mixture remained essentially the same. The general mixture contained the following: 500 g finely minced lean red meat (game, beef), one egg yolk, two tablespoons universal softbill food (optional), ½ cup Pronutro (Bokomo, original flavour), enough fresh blood (300 ml) from an abattoir to ensure the mixture was liquid, Avi-stress (Avi-Products), and engorged adult and nymph transmittable disease-free ticks (if available).

The red-billed oxpeckers were fed five times a day at 06h00, 10h30, 13h00, 15h30 and 18h00 during the 1988-1998 captures. Camera traps placed in the holding bomas with the oxpeckers during the 2012 captures showed that they rarely fed after 17h00. Consequently, the number of feeds per day was dropped from three to two, being around 06h00, 12h00 and/or 16h00.

For the 2012, 2013 and 2014 oxpecker captures, finely grated liver was also added as a supplement to the minced meat. Liver was grated using the medium holes of a shredder/grater. Abattoirs readily supplied condemned beef liver (not fit for human consumption) for this purpose. Oxpeckers belong to the same Sturnidae family as mynas (*Acridotheres tristis*) which are known for their sensitivity to iron (Klasing *et al.* 2012). Therefore, caution was taken with the amount of liver given to oxpeckers, once or twice a week was considered sufficient. Ticks can be used to supplement the oxpeckers' diet and to provide a more natural food source. Engorged female blue ticks *Boophilus decoloratus*, *B. microplus* and engorged bont tick nymphs *Amblyomma hebraeum* were best suited for feeding to oxpeckers in captivity. Some mixtures included wheat germ oil (one drop per oxpecker in the food mix twice a week). The food mixture must remain moist for at least 24 h. During this time, $^{1}/_{3}$ of the food mix`s weight is lost due to evaporation (pers. obs.). If the food mix is too dry, it becomes hard and inedible for oxpeckers (pers. obs.). As this is their only source of nutrition, it is essential that the moisture content be monitored constantly, especially on extremely hot days. An anti-coagulant was added to blood collected for oxpeckers for 1988-1998 captures (Table 2.1).

We mixed an anti-stress and vitamin supplement (such as Avistress, Avi-Products) with drinking water and food during the entire time that the oxpeckers are kept in captivity. The powder was lightly sprinkled over the food mixture and into the drinking water as per the instructions. Additional vitamin supplements and softbill food were given to enrich the birds' diet and provide some variety.

Data analyses

The South African Birds Atlas 1 project (SABAP 1) survey was conducted from 1987-1991 (Figure 2.2). The second survey, SABAP 2, started in 2007 and is ongoing (Figure 2.2). In SABAP 1, data on species' occurrences were collected at the Quarter Degree Grid Cell (QDGC) level. In SABAP 2, species occurrences were recorded at smaller pentad levels, where nine pentads are found in one QDGC. We obtained the red-billed oxpecker data for the changes in reporting rate for SABAP 1 and SABAP 2 from the SABAP2 website http://sabap2.adu.org.za/ (10/11/2016). Reporting rates are presence/absence data that show the proportion of checklist cards that a particular species was recorded on (Loftie-Eaton 2015).

To explore changes in reporting rates of red billed oxpeckers between SABAP 1 and 2, we used generalized linear models (GLMs) with a binomial distribution and logit link function using SPSS v. 24 (IBM Corp.). Variation in survey effort was accounted for by specifying the number of positive cards filled in and the total number of survey cards in each QDGC in each survey period (1 or 2) as a two-vector response variable. To account for non-independence due to repeated measurements of individual QDGCs, Generalized Estimating Equations with an exchangeable correlation matrix were used (Liang & Zeger 1986). Survey period was included as a fixed factor and significance was assessed using Wald chi-square statistics. Estimated reporting rates represent marginal means, back-transformed from the logit scale used for analysis.

Comparisons of reporting rate changes were done at the QDGC level and analysed in ArcGis 10.3. For each release site, the reporting rates for the QDGCs that the site encompassed and the surrounding QDGCs were determined and the nett change was calculated. Each release site was considered independently, even though a number of the sites shared some QDGCs (Table 2.2).

Results

There were 24 reintroductions of red-billed oxpeckers in South Africa (Figure 2.1) since 1988 and 13 population reinforcements (Table 2.2). A total of 1359 red-billed oxpeckers were relocated, with 598 of these occurring since the initiation of the Operation Oxpecker Project (Table 2.2). Oxpeckers were always released as one flock at the translocation sites. In 2007 and 2008, five birds from all captures in that year were taken to the Mokopane Biodiversity Conservation Centre as part of a captive breeding project and for research purposes. These birds were excluded from the translocation data.

Reporting rates of red-billed oxpeckers significantly increased from (mean ± SE) 23 ± 0.02% in SABAP1 to 27 ± 0.02% in SABAP2 (Wald $\chi^2 = 15.65$, df = 1, $P < 0.001$). Twenty-four per cent of the QDGCs (n = 170) showed an increase in reporting rates in southern Africa; 36% of the QDGCs showed a decrease in reporting rates (n = 258); and 14% of the QDGCs (n = 100) showed new areas where red-billed oxpeckers were being reported. In South Africa, red-billed oxpeckers had colonised several new areas, particularly surrounding areas where reporting rates had increased (Figure 2.2). Several of the colonised QDGCs were accompanied by QDGCs that had increased reporting rates (Figure 2.2). Twenty-six per cent of the QDGCs showed areas where reporting rates of red-billed oxpeckers were absent (n = 187); these areas are almost entirely in Botswana and Zimbabwe (Figure 2.2).

The comparisons of the changes in reporting rates for release sites and the immediate surrounding area are shown in Table 2.2. Only data for 23 release sites were included as the precise location of one of the first Limpopo Province releases is not known. All release sites showed a positive nett change in reporting rate (range 1 - 225), with the KwaZulu-Natal Province having the highest positive rates compared with the other provinces (Table 2.2). KwaZulu-Natal had 478 red-billed oxpeckers released and had a total nett change of 656 in reporting rates (Table 2.2).

Discussion

Translocations of red-billed oxpeckers in South Africa have been implemented over 26 years. The Operation Oxpecker Project monitors the survival of the birds through a colour ringing and reporting scheme, involving the management teams of the release areas, field staff, volunteers and tourists. This programme also employs the use of soft-releases (where birds are first kept in a holding aviary to allow acclimatisation) which are thought to have higher post-release survival rates then hard-releases (animals released directly into the wild) as found in other studies (Teixeira *et al.* 2007).

Red-billed oxpeckers are secondary cavity-nesters, so they cannot excavate their own nesting cavities and need to find suitable available cavities that occur naturally in the environment (Craig 2005). The placement of nest boxes at the release sites is an essential component of the programme, in order to promote breeding in their new site. This serves the added benefit of being able to monitor the reproductive success of the birds through monitoring all activities at the nest boxes. At the release site in Highflats, nest poles have been used extensively with two clutches of chicks being raised each year since their first release in 2013. The feedback received on sightings of the birds provides a further method of measuring reproductive success in these reintroductions, as all juveniles or adults without colour and metal rings can be considered progeny of the released individuals.

Bird atlasing assists in identifying trends in a bird species' range and possibly their abundance in an area (Loftie-Eaton 2015). This information also indicates changes that were possibly occurring in a bird's habitat (Loftie-Eaton 2015). Red-billed oxpeckers were until recently listed as *Near-Threatened* in South Africa (Craig 2005). As a result of their increased distribution range, the species has been down-listed to *Least Concern* (Taylor *et al.* 2015). The model by Griffith's *et al*. (1989) suggested that an estimated 80 individual animals must be released in order to increase the possibility of re-introduction success. Although only six of the 24 release sites received more than 80 individuals, it is clear from the nett reporting rate changes that releasing more red-billed oxpeckers into an area does not equate to a higher nett positive change in reporting rate (Table 2.2). However, EWT does aim to release ~50 red-billed oxpeckers at a new translocation site. This is done to ensure that there is still a viable population of red-billed oxpeckers should some birds not survive the translocation process or their new environment. The comparisons between SABAP1 and SABAP2 show that red-billed oxpeckers have undergone range changes in the past 20-30 years, which is further supported by the significant differences between reporting rates (Figure 2.2) (Loftie-Eaton 2015).

Reintroductions often suffer from monitoring programmes that are insufficient or ineffective (Ewen & Armstrong 2007). Sutherland *et al.* (2010) provided suggestions for ways to monitor bird reintroductions. These included estimating population changes using birth and death rates, documenting breeding (either through monitoring nests, finding juveniles, or a colour-ringing scheme where all non-ringed birds indicate successful breeding or dispersal events) or through recording presence/absence and changes in population abundance (Sutherland *et al.* 2010). Although our study has addressed some of these criteria, detailed population estimates for release sites would further substantiate our results. We suggest that any future reintroductions of red-billed oxpeckers contain a detailed post-release monitoring plan that addresses which of the above-mentioned methods will be used to determine the success of the reintroduction. Coupled with the recent down-listing of the species to *Least Concern* (Taylor *et al.* 2015), we demonstrate that translocations of red-billed oxpeckers in South Africa should be considered one of the more successful programmes of bird reintroductions for species recovery.

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Competing interests

The authors declare that they have no personal or financial relationships which may have inappropriately influenced them in writing this article.

Authors' contributions

All authors conceptualized the ms. L. C. collected data on red-billed oxpecker releases and M. J. analysed these with SABAP maps. All authors contributed to the writing of the paper.

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Legends for Figures

Figure 2.1. The capture and release sites for all red-billed oxpecker translocations since 1988 in South Africa. (Capture sites are shown in green and release sites in orange).

Figure 2.2. Change in reporting rates of red-billed oxpeckers in southern Africa. Red cells indicated areas where red-billed oxpecker sightings were reported in SABAP1 but not in SABAP2. Orange cells indicated areas where reporting rates had decreased from SABAP1 to SABAP2. Yellow cells indicated no change in reporting rates. Blue cells indicated new areas where red-billed oxpeckers were reported in SABAP2 but were not reported in SABAP1. Green cells showed an increase in reporting rates of red-billed oxpeckers. Clear cells were areas that have not yet been surveyed in either SABAP1 or SABAP2.

Figure 2.3. Graphic showing how Quarter Degree Grid Cells (QDGCs) were selected for determining the changes in reporting rates between the SABAP 1 and SABAP 2 projects. For each cell in which a particular red-billed oxpecker release site occurred, one blank surrounding cell was selected. The reporting rates for each of the selected cells were summed to give the nett change in reporting rate for the particular release site.

Tables

Table 2.1. Recipe for anti-coagulant for blood fed to red-billed oxpeckers in captivity.

Ingredients	**Amt. for 50ml of blood**	**Amt. for 2.5l of blood**
Glucose BP	1.79 g	9.25 g
Sodium Citrate Dihydrate	1.84 g	92.0 g
Citric Acid Monohydrate	228.9 mg	11.45 g
Sodium Acid Phosphate Dihydrate	175.7 mg	8.8 g
Distilled Water	70 ml*	3500 ml**

*These chemicals are mixed in distilled water to a final volume of 70 ml

**These chemicals are mixed in distilled water to a final volume of 3500 ml

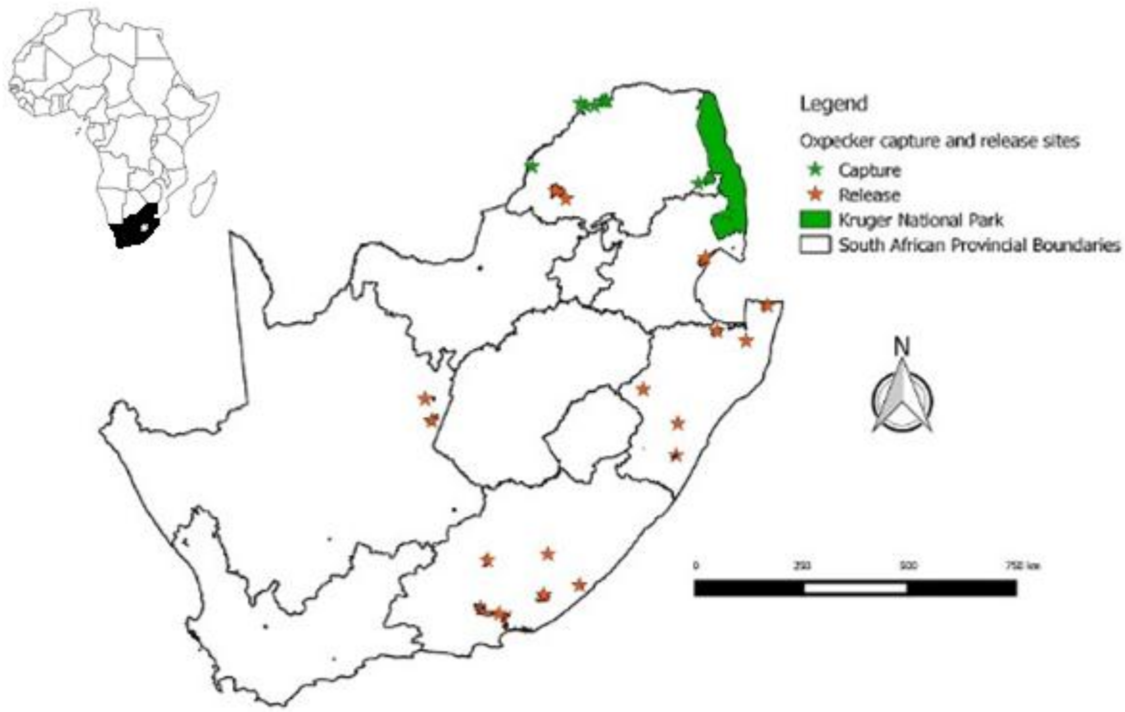
Table 2.2. Capture and release sites and number of red-billed oxpeckers translocated in South Africa since 1988, with corresponding changes in nett reporting rate from South African Bird Atlas Project (SABAP) data. Changes in nett reporting rate were calculated from the differences between SABAP1 and SABAP2 (Abbreviations: L= Limpopo, EC=Eastern Cape, M=Mpumalanga, NC=Northern Cape, KZN=KwaZulu-Natal).

Year	Capture site	Release site	Province	No. of oxpeckers released	SABAP reporting rate nett change
1988	Kruger National Park	Ben Lavin Nature Reserve	L	33	1
1988	Kruger National Park	Dennis Ball	L	26	Unknown
1988	Kruger National Park	Mara	L	22	40
1990	Kruger National Park	Addo Elephant National Park	EC	22	42
1990	Kruger National Park	Great Fish River Park	EC	29	
1990	Kruger National Park	Rockdale Farm	EC	29	8
1992	Kruger National Park	Mahushe Shongwe	M	22	44
1992	Kruger National Park	Songimvelo Nature Reserve	M	61	24
1993	Kruger National Park	Waterberg Conservancy – Lapalala Wilderness	L	99	182

1994	Kruger National Park	Ithala Game Reserve	KZN	98	225
1995	Kruger National Park	Marakele National Park	L	64	188
1996	Kruger National Park	Dundee Conservancy	KZN	102	59
1997	Kruger National Park	Tembe Elephant Park	KZN	103	106
1998	Kruger National Park	Shamwari Game Reserve	EC	51	38
2002	Kruger National Park	Hilton Conservancy, Queenstown	EC	18	
2002	Thabazimbi	Hilton Conservancy, Queenstown	EC	33	37
2003	Kruger National Park	Great Fish River Park	EC	82	98
2006	Platjan Farms	Spioenkop Dam Nature Reserve	KZN	33	38
2007	Platjan Farms	Hilton Conservancy, Queenstown	EC	39	37
2007	Platjan Farms	Mokopane Biodiversity Conservation Centre	L	5	
2007	Platjan Farms	Rooipoort, Kimberley	NC	2	
2007	Platjan Farms	Zululand Rhino Reserve	KZN	37	
2008	Platjan Farms	Game Valley, Howick	KZN	43	
2008	Platjan Farms	Hilton Conservancy, Queenstown	EC	11	
2008	Platjan Farms	Mokopane Biodiversity Conservation Centre	L	5	

2008	Platjan Farms	Rooipoort, Kimberley	NC	38	5
2008	Platjan Farms	Zululand Rhino Reserve, Mkuza	KZN	13	224
2009	Skukuza KNP	Game Valley, Howick	KZN	13	3
2009	Berlin Klaserie	Mpongo Private Nature Reserve	EC	42	
2010	Berlin Klaserie	Mountain Zebra National Park	EC	39	22
2010	Berlin Klaserie	Mpongo Private Nature Reserve	EC	9	
2010	Skukuza KNP	Mpongo Private Nature Reserve	EC	10	9
2012	Goedgedacht Farm	Mokala National Park	NC	21	
2013	Kruger National Park	Highflats, KwaZulu-Natal	KZN	16	
2013	Swartwater Farm	Mokala National Park	NC	37	
2014	Kruger National Park	Highflats, KwaZulu-Natal	KZN	20	1
2014	Kruger National Park	Mokala National Park	NC	32	3
Number of oxpeckers relocated since 2002				**598**	
Number of oxpeckers relocated since 1988				**1359**	

Figures



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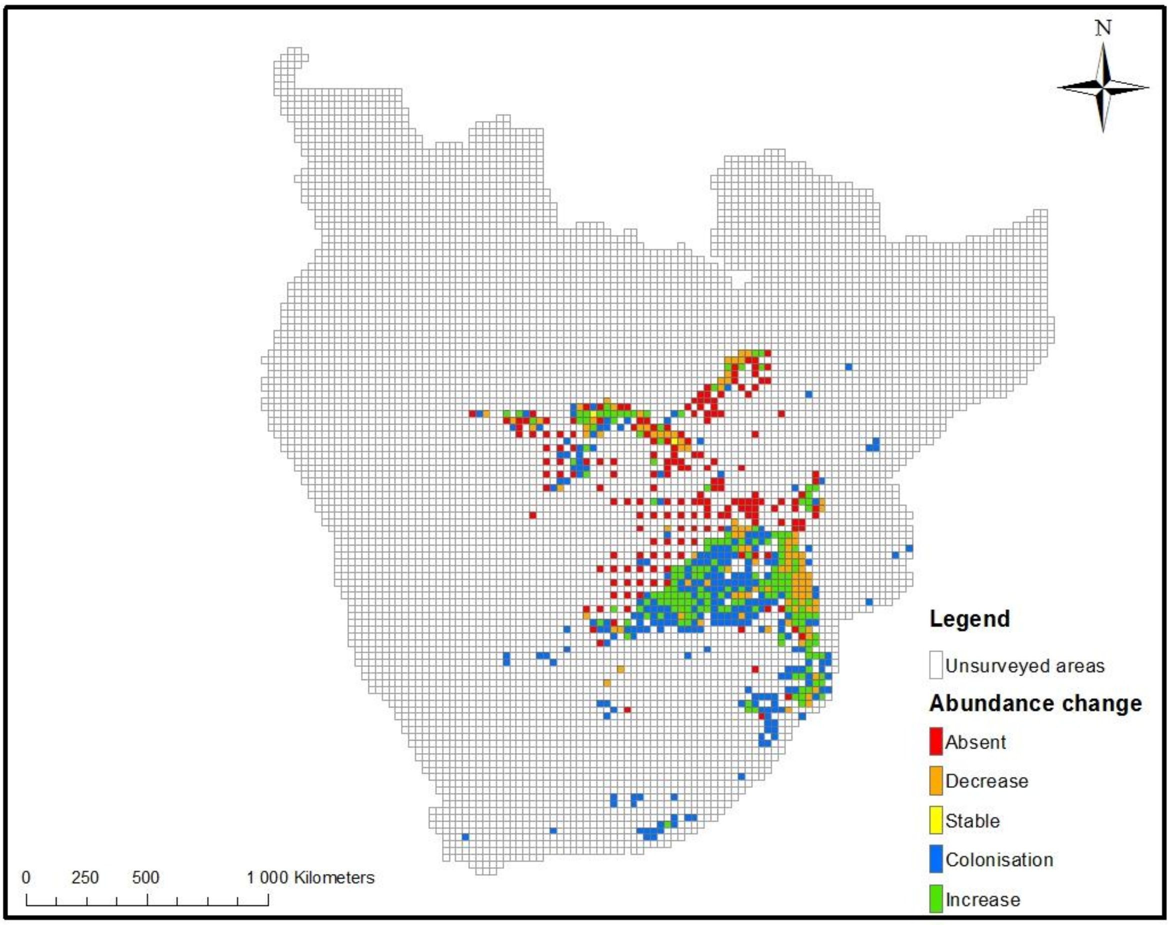

Figure 2.2. Change in reporting rates of red-billed oxpeckers in southern Africa. Red cells indicated areas where red-billed oxpecker sightings were reported in SABAP1 but not in SABAP2. Orange cells indicated areas where reporting rates had decreased from SABAP1 to SABAP2. Yellow cells indicated no change in reporting rates. Blue cells indicated new areas where red-billed oxpeckers were reported in SABAP2 but were not reported in SABAP1. Green cells showed an increase in reporting rates of red-billed oxpeckers. Clear cells were areas where red-billed oxpeckers have not yet been reported in either SABAP1 or SABAP2. There is a total of 715 QDGCs.

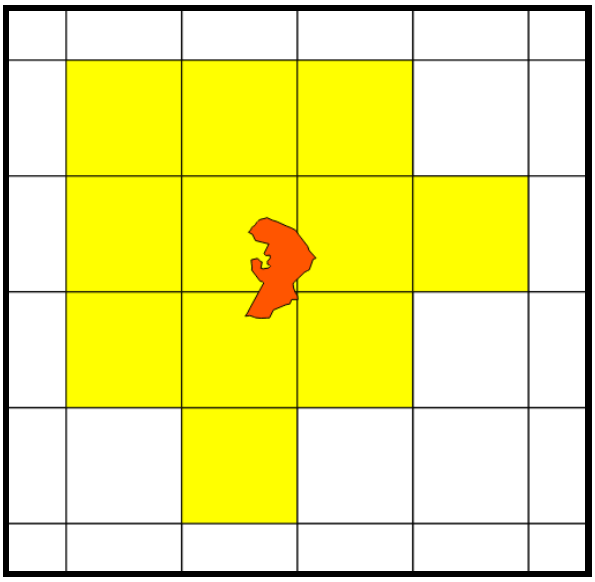

Figure 2.3. Graphic showing how Quarter Degree Grid Cells (QDGCs) were selected for determining the changes in reporting rates between the SABAP 1 and SABAP 2 projects. For each cell in which a particular release site occurred, one blank surrounding cell was selected. The reporting rates for each of the selected cells were summed to give the nett change in reporting rate for the particular release site.

CHAPTER 3

Translocations as a conservation tool for red-billed oxpeckers in KwaZulu-Natal, South Africa

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Running header: Translocations as a conservation tool for red-billed oxpeckers

Abstract

Translocations are human-mediated movements of organisms from one area and released in another. Red-billed oxpecker (*Buphagus erythrorhynchus)* populations had declined and gone locally extinct in many areas of South Africa. In 2002, The Endangered Wildlife Trust began translocating red-billed oxpeckers to areas where they had gone locally extinct as a conservation initiative for the species recovery. Consequently, we determined the presence or absence of red-billed oxpeckers at all the translocation release sites in KwaZulu-Natal where they were previously absent prior. In addition, we conducted transect surveys to determine red-billed oxpecker population estimates in Ithala Game Reserve (IGR) and Tembe Elephant Park (TEP). We also netted and ringed red-billed oxpeckers at these sites to obtain morphological and genetic data and to determine their breeding status. We distributed an online questionnaire to determine public perceptions on red-billed oxpecker's range expansion in South Africa. We analysed the SABAP data using general linear modelling and the survey data using the Distance Programme in R Studio. Red-billed oxpeckers were found to have persisted at all release sites as an indicator of success. Furthermore, trapped red-billed oxpeckers in ITG and TEP were unringed and several had brood patches. According to the best fit models, the group densities for IGR were 3.1 groups of oxpeckers/ha and 0.9 groups of oxpeckers/ha for TEP. The individual densities were 15.7 oxpeckers/ha for IGR and 1.8 oxpeckers/ha for TEP. Important factors affecting densities included host herd size, host species, type of land cover, and red-billed oxpecker flock size.

Conservation implication: A translocation is considered successful when a population is self-sustained through breeding of released individuals. Translocations of red-billed oxpeckers to KwaZulu-Natal, especially in IGR and TEP, were successful and highlight the effectiveness of this conservation tool for this species.

Key words: red-billed oxpecker, translocation, conservation, success, populations.

Introduction

There are numerous factors that contribute to an avian species becoming threatened and in need of increased conservation efforts for its survival. Compared with current fossil records, current extinction rates are higher than expected, emphasising the need for conservation (Barnosky *et al.* 2011). Translocations aim to increase the survival of threatened species, either for educational, scientific or for supportive purposes (Cromarty & Alderson 2013). Translocations are defined as "Human-mediated movement of living organisms from one area, with release in another" (IUCN/SSC 2013). Conservation translocations are further described as intentional movement and release of a living organism, where the primary objective is a conservation benefit to improve the conservation status of the focal species locally or globally, and/or restoring natural ecosystem functioning (IUCN/SSC 2013). One of these techniques is reinforcement, which is the intentional movement and release of organisms into an existing population of conspecifics (IUCN/SSC 2013). The other is re-introduction, where there is intentional movement and release of an organism inside its indigenous range from which it is locally extinct (IUCN/SSC 2013). Translocation is generally considered successful when the population is self-sustaining with breeding of released individuals and does not require further intervention (Griffith *et al.* 1989; Dodd & Siegel 1991; IUCN 1998; Seddon 1999).

Monitoring is crucial for reintroductions to determine their impact, however, it is costly and difficult to monitor all translocations closely (Ewen & Armstrong 2007). There is a degree of uncertainty that affects the success of translocation, as well as the rarity of the translocated species (Ewen & Armstrong 2007). In addition, unfocused data collection and monitoring regularly results in poor management decisions being made. If correct research questions are not identified before monitoring begins, there is a strong possibility that important data will not be collected or monitoring efforts may be misplaced where other projects may require them more (Romesburg 1981; Armstrong & Seddon 2007). Of concern, is that, the success of re-introductions has not increased over time (Fischer & Lindenmayer 2000). This questions its use as a conservation tool.

Oxpeckers are African passerine birds from the Sturnidae family (Zuccon *et al.* 2006; Lovette & Rubenstein 2007). Red-billed oxpeckers (*Buphagus erythrorhynchus)* begin their breeding season in September and end in March (Craig 2005; Sinclair *et al.* 2011). These birds are cooperative breeders and they often live together in fixed groups at all times (Du Plessis *et al.* 1995; Sinclair *et al.* 2011). Red-billed oxpeckers use grass, dung and mammal hair as nesting material (Plantan *et al.* 2014). Red-billed oxpeckers primarily feed on ticks, in addition to earwax, dung, urine, lice, mites, insects, dead pieces of skin, hair and excretions from the nose, eye and mouth of preferred large herbivore hosts (Bezuidenhout & Stutterheim 1980; Mundy 1983; Mooring & Mundy 1996). It is likely that oxpeckers select certain host species and that these key ungulates are essential in maintaining oxpecker populations (Grobler 1980).

Historically, red-billed oxpeckers had a distributional range that extended from Eritrea to Somalia, through south-eastern Sudan to Zimbabwe and into the former Transvaal, KwaZulu-Natal and Eastern Cape, South Africa (Stutterheim 1982). Prior to 1970, red-billed oxpeckers were mostly found in areas with a mean annual rainfall higher than 500 mm (Stutterheim 1982). However, there are records of red-billed oxpeckers found in areas with a lower mean annual rainfall of 205-500 mm (Stutterheim 1982). Oxpecker populations became threatened in South Africa in the early years of the 20th century. It was the culmination of the use of chemicals such as acaricides in cattle dips, the rinderpest epidemic that broke out in 1891 to 1897 and over-exploitation of wild game (Stutterheim 1982; Mundy 1983; Hall-Martin

1987). As early as 1890, it was accepted to use arsenic as an ingredient in cattle dips in the Eastern Cape (Stutterheim 1982). The decline in the oxpeckers was not only due to the poisoning of the birds themselves, but also from the lack of food (ticks) resulting from these dipping practices. With the local extinction of oxpeckers in most of their former range in South Africa, conservation efforts in the 1980s onwards have attempted to deal with the factors causing their demise.

With the development of oxpecker friendly acaricides, oxpecker populations slowly recovered as a result (Plantan *et al.* 2014). However, their distribution was confined to game reserves, game farms and areas with undipped cattle or the use of oxpecker friendly dips (Stutterheim 1982). In 2002, The Endangered Wildlife Trust (EWT) started an oxpecker capture programme, named Operation Oxpecker (Brooks 2008). Their goal was to capture red-billed oxpeckers on cattle farms and protected areas in northern Limpopo and translocate them to various farms and game reserves, where they had previously gone locally extinct in South Africa (Brooks 2008; Plantan *et al.* 2014). Currently, they have been recorded in Namibia, Angola, Botswana, Zimbabwe, Zambia, Mozambique and as far as Kenya (SABAP 2). In South Africa, they are most common in Limpopo, Gauteng and KwaZulu-Natal Provinces (KZN) (SABAP 2). Although oxpecker populations are increasing, they still need to be protected in South Africa (Plantan *et al.* 2014).

There are 24 sites in South Africa where red-billed oxpeckers were translocated and released (Chapter 2). There are no current accurate population estimates available at these release sites in South Africa. We focused our research in KZN, where seven sites received translocated red-billed oxpeckers: Tembe Elephant Park (TEP), Ithala Game Reserve (IGR), Zululand Rhino Reserve (Zululand), Dundee Conservancy (Dundee), Spioenkop Dam Nature Reserve (Spioenkop Dam), Game Valley Howick (Howick), and Highflats near Ixopo (Ixopo) (Figure 3.1). We therefore investigated the success of red-billed oxpecker translocations and

(1) determined the presence or absence of red-billed oxpeckers at all the translocation release sites in KZN where they had been absent prior to these releases. In addition, we conducted (2) transect surveys to determine red-billed oxpecker population estimates in IGR and TEP. We also (3) netted and ringed red-billed oxpeckers at these sites to obtain morphological and genetic data and to determine their breeding status. We distributed an (4) online questionnaire to determine public perceptions of red-billed oxpecker's range expansion in South Africa. We predicted that translocation was an effective conservation tool for this species' recovery in South Africa, particularly KZN.

Methods

Presence of red-billed oxpeckers at translocation sites in KZN

We visited the seven sites that received translocated red-billed oxpeckers over the years: TEP, IGR, Zululand Rhino Reserve (Zululand), Dundee Conservancy (Dundee), Spioenkop Dam Nature Reserve (Spioenkopdam), Game Valley Howick (Howick), and Highflats near Ixopo (Ixopo) (Figure 3.1) during 2015-2016 and visually confirmed the birds' presence there.

In addition, we conducted transect surveys in IGR (*27°30′57″S 31°19′53″E*) and TEP (*27°02′55″S 32°25′20″E*) so present details of these. IGR is 29 653 ha compared with TEP that is 30,012 ha (Johnson 1990; Matthews *et al.* 2001). IGR has annual rainfall ranges from 500 to 1200 mm, with an average of 791 mm p.a., where the majority falling in summer (Wiseman 2001), whereas TEP has annual rainfall that ranges from 245 to 2105 mm, however, on average the park receives 722 mm p.a. (Matthews *et al.* 2001).

Summer temperatures range from 18 to 30^{o}C and winter temperatures range from 15 to 25^{o}C in IGR. On odd occasions, temperatures may reach 40^{o}C in summer and freezing point in winter (Johnson 1990). Temperatures in TEP range from a minimum of 9^{o}C to a high of 31.5^{o}C (Matthews *et al.* 2001).

The altitudes in IGR range from 350 to 1450 m asl, which results in varied topography that changes from hilly grasslands, steep valleys, open woodlands to bushveld and savannah habitats (Johnson 1990). There are three main veld types in IGR: Natal central bushveld, north-eastern mountain grassland and natal Lowveld bushveld (Johnson 1990). In contrast, the topography is relatively flat in TEP, interspersed with relic sand dunes that reach a height of 129 m asl and the lowest areas have an altitude of 50 m asl (Matthews *et al.* 2001). Sand forests are found here, with grasslands bordering them (Matthews *et al.* 2001). Other vegetation to be found range from Muzi Swamp, palmveld and bushveld (Matthews *et al.* 2001). In 1994, 98 red-billed oxpeckers were released into IGR, and in 1997 103 red-billed oxpeckers were released into TEP (Table 3.1).

Oxpecker transect surveys were conducted by vehicle during summer and the breeding season of red-billed oxpeckers in IGR and TEP. They were done on three separate days in IGR (19/11/2015, 13/01/2016 and 15/01/2016) and on four days in TEP (21/11/2015, 22/11/2015, 22/01/2016 and 23/01/2016). There was one observer and an assistant to record sightings, as well as the driver. Transects were driven on roads only accessible to tourists, therefore the number of transects differed between IGR and TEP and distances differed between transects (Table 3.2). We surveyed nine transects in IGR and 20 transects in TEP, where each transect was chosen randomly, ensuring that each transect was driven in a different direction. Surveys started at 06h30 and ended at 15h00 the same day. All transect were driven in one day in IGR and over two days in TEP. A speed of 25-30 km/h was driven and absence or presence of oxpeckers were determined. All potential red-billed oxpecker hosts was inspected for oxpeckers feeding on them. If no oxpeckers were seen on a host, the observation was recorded as absent of oxpeckers. In addition to presence of oxpeckers we recorded how many oxpeckers were present and if there were any juveniles in an observation. Sightings of red-billed oxpeckers that were seen on stationary objects such as telephone poles or trees were similarly recorded (Group D). Each observation recorded the coordinates of the sighting, the host species, and the total number of hosts at the time of the observation. In addition, the perpendicular distance (m) of the animals from the vehicle were recorded, using a monocular range finder (Laser range finder LRS-800, Ranger, Cape Town).

Observations were collected in accordance with Distance sampling assumptions (Borchers *et al.* 2002; Johnson 2008). These assumptions were: all birds are detected at zero distance; detectability would decline with an increase in distance; birds did not take flight in response to the observer; estimations of distances were accurate; and birds that were observed were independently distributed along the transect line (Borchers *et al.* 2002; Johnson 2008).

Trapping red-billed oxpeckers in IGR and TEP

We trapped red-billed oxpeckers in IGR (18/11/2015 and 14/01/2016) and TEP (20/11/2015, 18/01/2016, 19/01/2016, 20/01/2016 and 21/01/2016). We used an animal decoy and placed it at a waterhole and surrounded the decoy with mist nets (Figure 3.2). We only set up mist nets in open areas near water sources, and started setting up at 02h00 before sunrise. It was important to set up before birds became active as red-billed oxpeckers were suspicious of any activity with the decoy. We put two mist nets together, one on top of the other, and placed three sets in the shape of a triangle (Figure 3.2). The lowest shelf was placed on the ground to prevent red-billed oxpeckers from escaping under the net (Figure 3.2). We used a total of four 12 m and two 6 m nets to create the triangle (Figure 3.2). The total height of the trap was five to six metres tall (Figure 3.2). We secured guy ropes to the top and centre of the poles to stabilize the trap and keep tension on the nets (Figure 3.2). We placed the decoy in the centre of the triangle (Figure 3.2). The decoy was made from a 210 L plastic barrel with chicken wire mesh wrapped around it (Figure 3.2). This barrel was placed on top of a stand and a tanned zebra skin draped over it (Figure 3.2). The chicken mesh prevented the skin from sliding off the barrel. We used duct tape to secure the skin to the barrel and stand. Total time spent setting up the trap and nets was ~150 min. Trapping only took place when there was little wind and no precipitation as this made nets visible or made handling of birds difficult. The trap was also taken down if temperatures became too hot or the wind speed increased. We trapped at different sites within the reserves to prevent the red-billed oxpeckers becoming familiar with the trap and nets.

Once caught, standard morphological measurements, including wing, tail and body mass, were recorded for each red-billed oxpecker. In addition, age of the bird and primary wing moult were noted. Evidence of a brood patch was checked to determine breeding status of the bird. We collected a drop of blood from the brachial vein for later sex determination, relatedness to other individuals, and for overall population genetic analyses. These will further support success of the release and range expansion. To collect blood from the brachial vein, it was first cleaned using cotton wool dipped in 70% ethanol. A 3.0 ml insulin needle was used to puncture the vein and blotting paper was used to collect the drops of blood sample. Pressure was then applied to the vein with cotton wool to stop any further bleeding and prevent the development of any haematoma.

In order to collect a feather sample for later isotopic analysis, the tip of the right tail feather (R12) was clipped. A maximum length of 1 cm was clipped. If loose feathers were found on the individual, those were collected instead of clipping the tail feather. This included downy feathers. Any faecal samples or ectoparasites were collected opportunistically for further analyses. Any un-ringed birds were fitted with metal rings (issued by Afring) on their right leg by a qualified ringer. In addition, colour rings were fitted on the red-billed oxpecker's left leg. Colours were specific to each trapping site: IGR had white colour rings while TEP had yellow.

Red-billed oxpeckers that were caught were released where they were caught immediately after measurements were complete. All ringing data were submitted to the Afring database.

Questionnaires

To obtain data on the public's knowledge and perceptions about presence of red-billed oxpeckers on their properties and local environ, we created an online survey (Appendix 3.1) using Google forms requesting any observational data of red-billed oxpeckers in the participant's area. The link was online from 12/08/2016 to 28/11/2016. We emailed the link of the survey to all chairpersons of Birdlife South Africa, Conservancies of KZN, KwaZulu-Natal Agricultural Union Kwanalu, Ezemvelo KZN Wildlife managers, and EWT. We advertised the questionnaire in a South African weekly magazine, the Farmer's Weekly. We also asked those that completed the questionnaire to forward the link to people in their contact list that would be interested in completing the questionnaire.

Data analyses

We analysed the survey data from IGR and TEP in R studio 0.99.896 (R Core Team 2015) using the Distance and Distance2 package (Miller 2014; Miller 2015). We assessed the survey data using different key functions and adjustment terms for the different covariates and combinations thereof. We also tested the null hypothesis, where no covariates did not affect the probability of detection. We tested the data with Half-normal, Hazard-rate and Uniform key functions and used Cosine, Simple Polynomial and Hermite adjustment terms. Because of the differences in habitat, observation distances were longer in IGR (mean distance = 115.8 m) and shorter in TEP (mean distance = 38.4 m). As a result, we truncated the distances for IGR at 300 m and at 200 m for TEP. The covariates were the distances from the car, host species group, type of land cover, time of day, the number of host individuals in a herd, and flock size of red-billed oxpeckers. We used ArcMap 10.3 to identify the land cover at the points of observations. Host species could not be assessed separately, so they were grouped according to average body mass (Skinner & Chimimba 2005, Smithers 2012). Group A was the smallest herbivores and group C was the largest (Table 3.3). Group D lists sightings of red-billed oxpeckers that were not on host herbivores, but rather on stationary objects such as trees or telephone poles (Table 3.3). Effort was recorded as length of transect driven. For each study site we selected the best fit model according to the lowest Akaike's Information Criterion (AIC) and Akaike's weights (Δ AIC) and value, and plotted them in a graph. Δ AIC was the difference calculated between the AIC values and the AIC value of the best fit model. Group densities are the number of flocks of red-billed oxpeckers and individual densities are of individual red-billed oxpeckers. Densities were calculated per ha.

Results

Before translocations took place in KZN, red-billed oxpeckers were absent from all the release sites. The first recorded KZN translocation release took place in IGR, 22 years ago, with the most recent release in Ixopo, two years ago (Table 3.1). During 2015-2016 we observed red-billed oxpeckers present at the seven release sites in KZN, confirming their persistence at these localities following the respective translocations (Table 3.1). In the IGR and TEP surveys, we observed adult red-billed oxpeckers mating and collecting nesting material as well as juvenile red-billed oxpeckers feeding from hosts in family groups.

In IGR, red-billed oxpeckers were seen 8% (N = 33) of the total of 391 observations made. In TEP, red-billed oxpeckers were observed 6% (N = 24) of the total 378 observations made. The key function that best fitted the data was half-normal with the cosine2 adjustment. According to the best fit models, the group densities for IGR were 3.1 groups of oxpeckers per ha and 0.9 groups of oxpeckers per ha for TEP (Tables 3.4 and 3.5). The individual densities were 15.7 oxpeckers per ha for IGR and 1.8 oxpeckers per ha for TEP (Tables 3.4 and 3.5). Abundance of red-billed oxpeckers was calculated to be 927.3 at group level and 4653.9 at an individual level in IGR (Table 3.4) while in TEP it was 254.1 at group level and 534.0 at an individual level (Table 3.5).

Covariates that best fitted the presence of red-billed oxpeckers in IGR were flock size, host herd size and land cover (AIC = 334.97) (Table 3.4). The highest Δ AIC was 10.27 for IGR and 4.39 for TEP (Table 3.4 and 3.5). Covariates that best fitted the presence of red-billed oxpeckers in TEP were land cover and host group (AIC = 251.59) (Table 3.5). Observation distances were shorter when land cover was thicker. Open land cover allowed observers to record sightings at greater distances and more observations were made. The probability of detection decreased as distance increased. In IGR, there was a higher detection probability in open bush and when there were ten or more host individuals in a herd (Figure 3.3). Red-billed oxpeckers were less likely to be detected in dense bush and when there was a single host individual present (Figure 3.3). Flocks of red-billed oxpeckers with numbers of four or less were less likely to be detected (Figure 3.3). In TEP, there was a higher detection probability of red-billed oxpeckers when the land cover was grassland and when oxpeckers were present on other objects (Figure 3.4). Detection probabilities were lowest in dense bush and on small herbivores in TEP (Figure 3.4).

We caught nine adult red-billed oxpeckers in IGR, (three (33%) had brood patches), while in TEP 25 were caught (five (20%) with brood patches). At TEP three (12%) caught were juveniles. Mean body mass, wing length, and tail length of red-billed oxpeckers in IGR and TEP were similar (Table 3.6). Sex determination and genetic relatedness results are still pending (corollary study).

We received few responses from the online questionnaire (N = 15) in South Africa. Of the responses, 14 were from Caucasians and one was from an African. The youngest age group that responded was in the category 30 – 39 years old. The provinces that responded were: Gauteng (N = 5), KZN (N = 3), Eastern Cape (N = 3), Mpumalanga (N = 1), Limpopo (N = 2) and the North West Province (N = 1). Seven of the responses were land owners, three were livestock farmers, one a game farmer, two conservancy managers and one a game reserve manager. Some were able to report when they first noticed red-billed oxpeckers present on their properties. One from Dundee, KZN, stated he first noticed them in 2013. The other farmer first noticed red-billed oxpeckers in 2000 on their farm in the North West Province. The Kube Yini Private Game Reserve in Mkuze has had red-billed oxpecker present since 2000. Red-billed oxpeckers are occasionally seen on a conservancy in the North Western Province. Red-billed oxpecker were seen every day in Mokopane, Lephalale, Dundee and Mkuze, however most of the flocks seen numbered less than 10 individuals. All respondents stated that they believed red-billed oxpeckers provided a service by controlling the tick load on animals.

Discussion

Red-billed oxpeckers were observed at all their release sites in KZN supporting the use of translocation as a conservation tool for this species' survival and renewed presence in its former range. In addition, this was the first study to determine the densities of red-billed oxpeckers at their translocated sites and analyse factors, such as land cover and host herd size, which affect this. Previous studies have used oxpecker: cattle ratios to estimate population numbers of oxpeckers in a given area (Stutterheim & Panagis 1985; Robertson & Jarvis 2000). However, this leads to underestimations, because other hosts are excluded (Robertson & Jarvis 2000). Another study had done ground counts of red-billed oxpeckers and their mammal symbionts (Stutterheim & Stutterheim 1980). The oxpecker to mammal ratios that were generated showed that red-billed oxpecker populations had increased (Stutterheim & Stutterheim 1980). The inclusion of absence data eliminates the possibilities of bias that may have resulted from variables such as the time of day and water sources (Stutterheim & Stutterheim 1981). In addition, absence data allows for more reliable population estimates, by analysing the presence and absence of red-billed oxpeckers.

Red-billed oxpecker population's persistence in an area depend on their breeding success, mortality rates and movements (Stutterheim & Stutterheim 1981). Generally, when high rainfall occurs, vegetation increases as do tick populations (Stutterheim & Stutterheim 1980). Tick populations decline when there is overgrazing as they do not survive well on open plains (DeMatos 2008). In addition to more vegetation, the ungulate host populations also generally increase with increased rainfall (Stutterheim & Stutterheim 1980). Consequently, this improved food supply positively affects red-billed oxpeckers as older and younger birds are able to find food more easily (Stutterheim & Stutterheim 1980). This in turn increases the overall population of the red-billed oxpecker (Stutterheim & Stutterheim 1980).

AIC values provide us with a variety of models and by comparing them through Δ AIC, we were able to determine our best fit model (Symonds & Moussalli 2011). The results were not indicative of red-billed oxpecker preferences, but rather showed the probability of detecting them in IGR and TEP respectively. A factor important in determining densities of red-billed oxpecker populations was availability of open areas in both IGR and TEP. Open areas may make it easier for red-billed oxpeckers to locate hosts to feed from (Grobler 1979). The type of host and the host herd size were also important factors in determining oxpecker densities. Herbivores that formed large herds, increased the probability of red-billed oxpeckers visiting them. Larger sized hosts are generally preferred by red-billed oxpeckers, as these herbivores have a higher adult tick load (Hart *et al.* 1990). However, red-billed oxpeckers were often observed on smaller host herbivores (pers. obs.). Smaller hosts, such as impala (*Aepyceros* *melampus*), have been reported to have fewer adult ticks, but have more ticks in the larval or nymph stages (Hart *et al.* 1990). Impala often form large herds that integrate with other host species, for example, zebra (*Equus quagga*) (Jarman 1978). Ultimately, oxpeckers will generally maximise their food intake and decrease their search time (Grobler 1980; Hart *et al.* 1990; Mooring & Mundy 1996; Mooring & Mundy 1996). Therefore, red-billed oxpeckers will opportunistically feed from smaller hosts. One land owner noted an increase in red-billed oxpeckers when he changed from livestock to game farming (R. Erasmus pers. comm.). Consequently, a variety of hosts may be important in maintaining healthy populations of red-billed oxpeckers.

There are several possibilities for the low percentage of red-billed oxpeckers detected in IGR and TEP. Red-billed oxpeckers were best detected when they were calling (pers. obs.). We suggest that transect surveys be conducted until the number of red-billed oxpeckers detected is higher. In IGR, 33 red-billed oxpeckers were seen out of 391 observations (8%), the percentage of oxpeckers seen should be higher. In addition, we had only surveyed the roads accessible to tourists. Future surveys should consider including management roads to increase the area surveyed. As this research was done during the oxpeckers breeding season (summer), additional population surveys should be conducted to determine whether there is a seasonal effect on red-billed oxpecker population number and densities.

A translocation is successful when the population is self-sustained by the breeding of the released individuals and does not require any further intervention (Griffith *et al.* 1989; Dodd & Siegel 1991; IUCN 1998; Seddon 1999). We found the red-billed oxpecker translocations in KZN were successful. We caught red-billed oxpeckers that were breeding, confirmed by the presence of a brood patch, as well as juvenile oxpeckers. We also observed adult red-billed oxpeckers mating and collecting nesting material as well as juveniles feeding in family groups. Red-billed oxpeckers in KZN appear to be increasing and dispersing from their original translocation release sites so increasing their distributional range in KZN (Chapter 2). This was further confirmed by landowners who reported the first time red-billed oxpecker had been observed on their properties and their continued persistence away from release sites.

As predicted, success of red-billed oxpecker translocations support that it is an effective conservation tool for their recovery in South Africa, particularly KZN. Although red-billed oxpecker populations are increasing in numbers as well as in their distributional range in South Africa, they still need to be protected here (Plantan *et al.* 2014). Their translocations to KZN have been successful, factors that influence their future translocation success can be divided into ecological and non-ecological factors. Ecological factors include the quality of the habitat, genetics, predation, competition and breeding difficulties (Fischer & Lindenmayer 2000). Non-ecological factors include education and public relations, team management, legal considerations and project costs, and the amount of time dedicated to the translocation project (Fischer & Lindenmayer 2000). Future translocation events of red-billed oxpeckers need to state whether they have addressed these issues and conducted post-release monitoring as often as possible, following a management plan, after the birds have been released.

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Legends for Figures

Figure 3.1. Map of red-billed oxpecker translocation release sites in KwaZulu-Natal, South Africa, which were assessed in the current study.

Figure 3.2. Decoy (A and B) and net trap set up (C) to net for red-billed oxpeckers in the current study.

Figure 3.3. Mean half-normal function with cosine2 adjustment detection probabilities (A) for land cover (B), host number (C) and flock size (D) for red-billed oxpeckers in Ithala Game Reserve, KwaZulu-Natal, South Africa.

Figure 3.4. Mean half-normal function with cosine2 adjustment detection probabilities (A) for land cover (B) and host group preferences (C) for red-billed oxpeckers in Tembe Elephant Park, KwaZulu-Natal, South Africa. (See Table 3.2 for host group).

Tables

Table 3.1. The year and number of red-billed oxpeckers translocated to various sites in KwaZulu-Natal, South Africa (Chapter 2).

Year	Translocation site	Number of red-billed oxpeckers
1994	Ithala Game Reserve	98
1996	Dundee Conservancy	102
1997	Tembe Elephant Park	103
2006	Spioenkop Dam Nature Reserve	33
2007	Zululand Rhino Reserve	37
2008	Karkloof Spa Reserve, Howick	43
2008	Zululand Rhino Reserve	13
2009	Karkloof Spa Reserve, Howick	13
2013	Highflats, near Ixopo	16
2014	Highflats, near Ixopo	20

Table 3.2. Distances and names of transect driven in Ithala Game Reserve (IGR) and Tembe Elephant Park (TEP) KwaZulu-Natal.

IGR		TEP	
Transect name	Distance (m)	Transect name	Distance (m)
Onverwacht	6500	Gwanini	17000
Kwanosazana	2100	Dube	3200
Road to loop	3000	ESR	9000
Ngulubeni	8000	Ezinaleni	11500
Dakaneni	15000	Ezinaleni pans	250
Ngubhu	13500	Field office road	700
Field office road	7400	Khobe	4000
Dlabe	4500	Vukazeni	1300
Main road	6200	Mahlasela	4700
		Mahlasela hide	500
		Manungu	7000
		Masizwana	3300
		Mkhaya	4000
		Mkhombe	3450
		Odongweni	6800
		Sigwadi	4500
		Ponweni	2500
		WSR	8000
		Mfungeni pan	800
		Mkhulu	2700

Table 3.3. Host herbivores grouped according to body mass (kilograms).

A (55 – 140 kg)	B (230 – 700 kg)	C (1200 – 24000 kg)	D
Warthog (*Phacochoerus africanus*)	Greater kudu (*Tragelaphus strepsiceros*)	Giraffe (*Giraffa camelopardalis*)	Stationary objects
Impala (*Aepyceros melampus*)	Blue wildebeest (*Connochaetes taurinus*)	White rhinoceros (*Ceratotherium simum*)	
Bushbuck (*Tragelaphus scriptus*)	Plains zebra (*Equus quagga*)	African elephant (*Loxodonta africana*)	
Nyala (*Tragelaphus angasii*)	Waterbuck (*Kobus ellipsiprymnus*)		
Tsessebe (*Damaliscus lunatus*)	Cattle (*Bos taurus*)		
Southern reedbuck (*Redunca arundinum*)	Eland (*Taurotragus oryx*)		
Red hartebeest (*Alcelaphus buselaphus*)	African buffalo (*Syncerus caffer*)		

Table 3.4. Half-normal function with cosine2 adjustment fitted to different models to determine group and individual densities and abundances of red-billed oxpecker per hectare for Ithala Game Reserve, KwaZulu-Natal, South Africa.

					Group		Individual	
Model	**Number of parameters**	**P_a**	**AIC**	**Δ AIC**	**Density**	**Abundance**	**Density**	**Abundance**
Host number, flock size, land cover	4	0.21	334.97	0	3.1	927.3	15.7	4653.9
Host number, land cover	3	0.24	336.05	1.08	2.8	835.9	8.9	2648.4
Land cover, host group	3	0.21	337.43	2.46	3.2	960.3	9.3	2759.8
Flock size, host group	3	0.22	338.15	3.18	3.0	890.4	12.3	3639.5
Host number	2	0.28	339.55	4.58	2.4	713.2	8.3	2468.1
Host number, flock size	3	0.28	341.54	6.57	2.4	712.7	8.4	2502.5
Flock size, land cover	3	0.24	342.2	7.23	2.8	820.3	15.1	4488.1
Host number, flock size, time	4	0.77	343.54	8.57	2.7	788.3	6.0	1791.7
Land cover	2	0.28	344.27	9.3	2.4	709.7	7.8	2323.5
Flock size, time	3	0.28	345.24	10.27	2.4	713.8	9.6	2843.7

Table 3.5. Half-normal function with cosine2 adjustment fitted to different models to determine group and individual densities and abundances of red-billed oxpecker per hectare for Tembe Elephant Park, KwaZulu-Natal, South Africa.

					Group		Individual	
Model	**Number of parameters**	**P_a**	**AIC**	**Δ AIC**	**Density**	**Abundance**	**Density**	**Abundance**
Land cover, host group	3	0.81	251.59	0	0.9	254.1	1.8	534.0
Host group	2	0.55	253.73	2.14	1.3	381.7	3.3	987.0
Host group, host number	3	0.57	253.81	2.22	2.9	873.2	9.2	2719.0
Flock size	2	0.49	254.52	2.93	1.5	437.3	3.9	1167.1
Host group, time	3	0.56	254.56	2.97	1.3	443.3	3.3	1331.5
Host group, time, host number	4	0.58	255.22	3.63	2.9	851.5	9.2	2734.7
Host number	2	0.48	255.4	3.81	1.5	447.4	4.6	1351.0
Flock size, host number	3	0.53	255.45	3.86	1.3	383.9	2.6	789.4
Time	2	0.49	255.64	4.05	1.5	438.2	4.5	1334.7
Flock size, host number, time	4	0.52	255.98	4.39	1.4	410.4	2.8	825.2

Table 3.6. Mass (g), wing and tail lengths (mm) of red-billed oxpeckers caught in Ithala Game Reserve (IGR) (N = 9) and Tembe Elephant Park (TEP) (N = 25).

	Body mass (g)		Wing (mm)		Tail (mm)	
	IGR	TEP	IGR	TEP	IGR	TEP
Min	40	40	103	110	92	89
Max	55	65	121	122	105	104
Mean ± SE	50 ± 1.6^a	51 ± 1.2^a	115 ± 1.8^b	116 ± 0.8^b	97 ± 1.6^c	96 ± 0.7^c

Figures

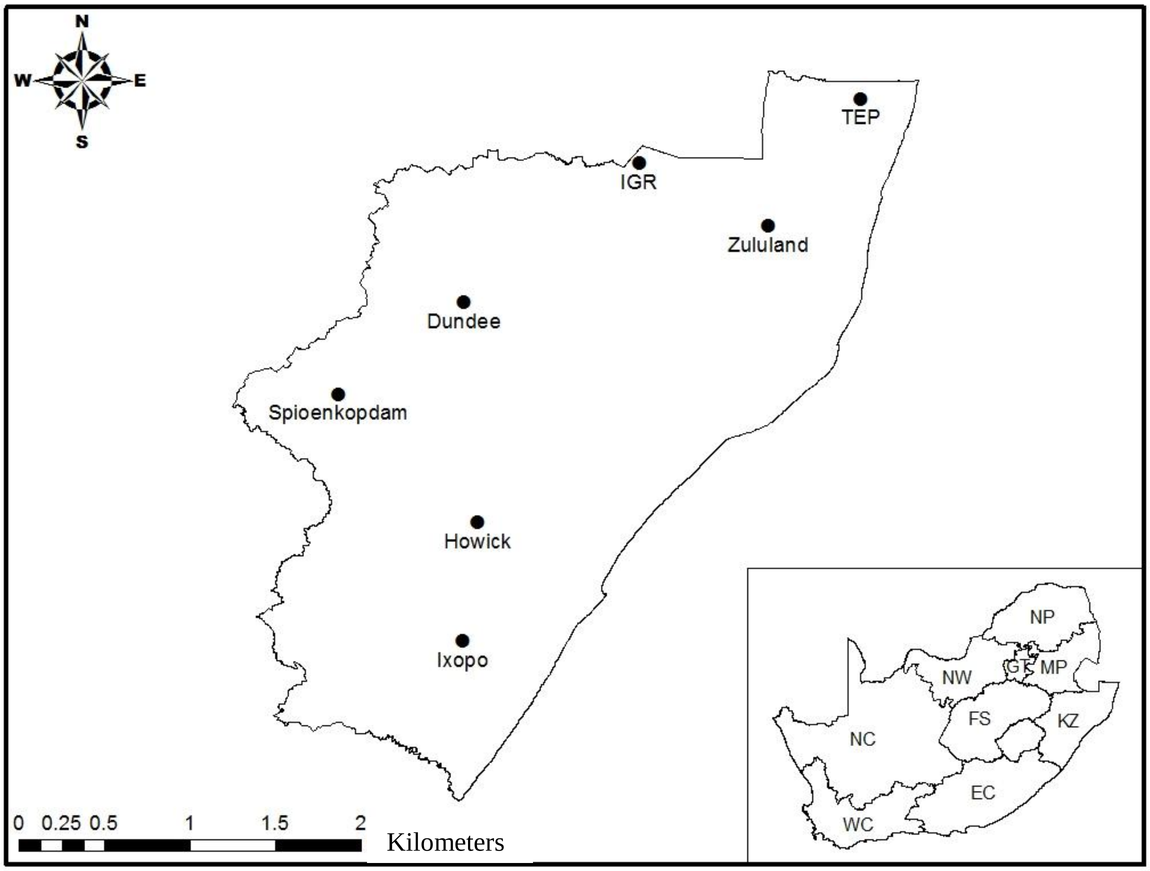

Figure 3.1. Map of red-billed oxpecker translocation release sites in KwaZulu-Natal, South Africa which were assessed in the current study.

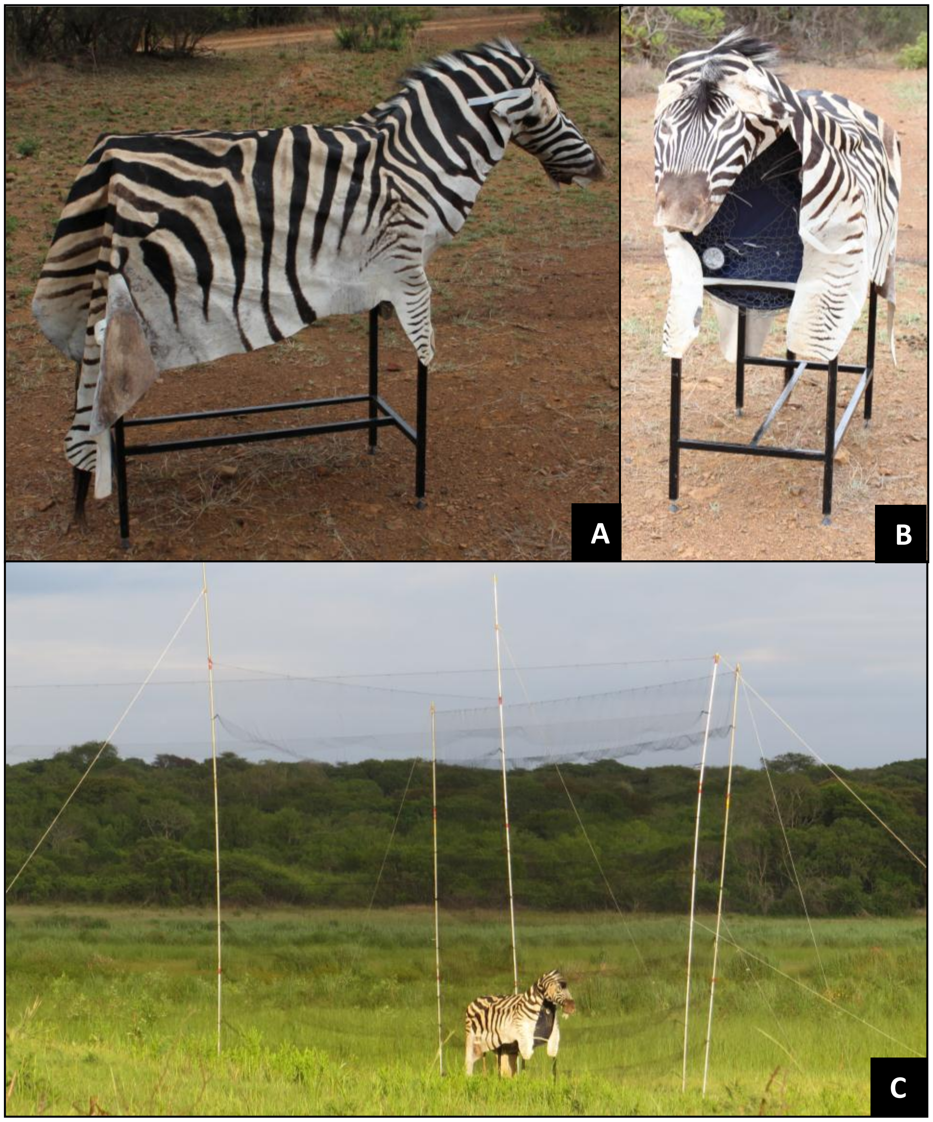

Figure 3.2. Decoy (A and B) and net trap set up (C) to net for red-billed oxpeckers in the current study.

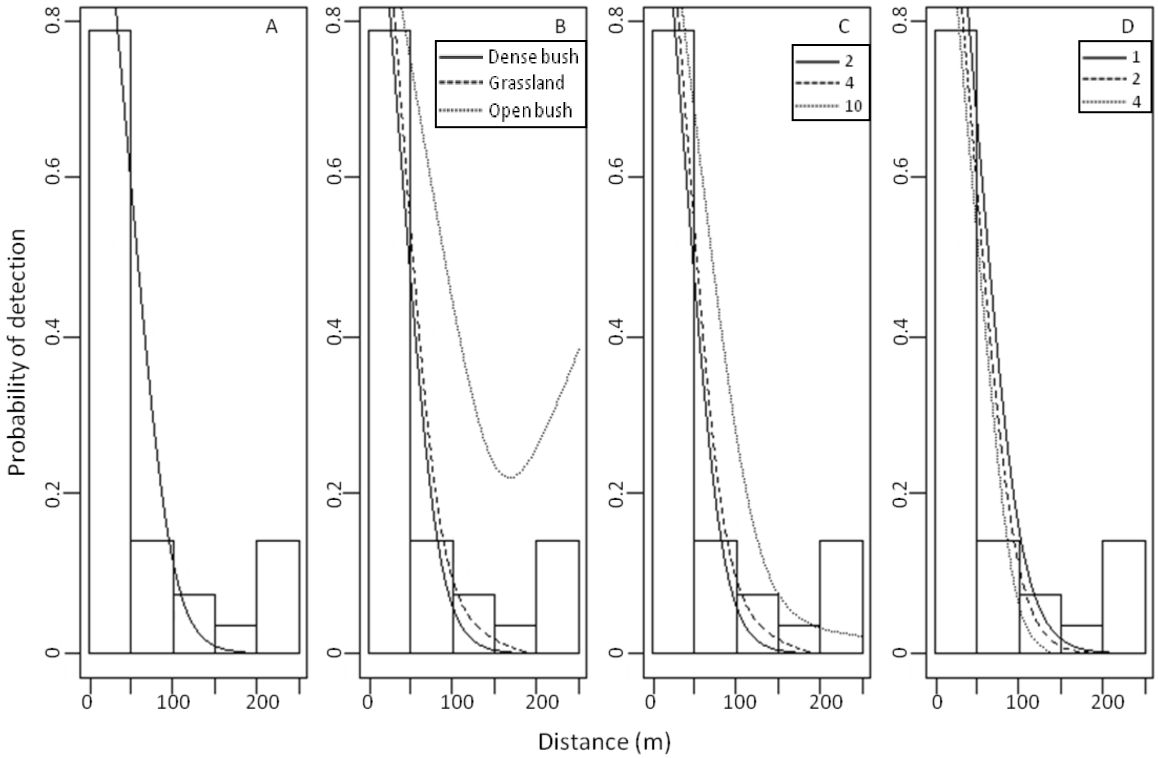

Figure 3.3. Mean half-normal function with cosine2 adjustment detection probabilities (A) for land cover (B), host number (C), and flock size (D) for red-billed oxpeckers in Ithala Game Reserve, KwaZulu-Natal, South Africa.

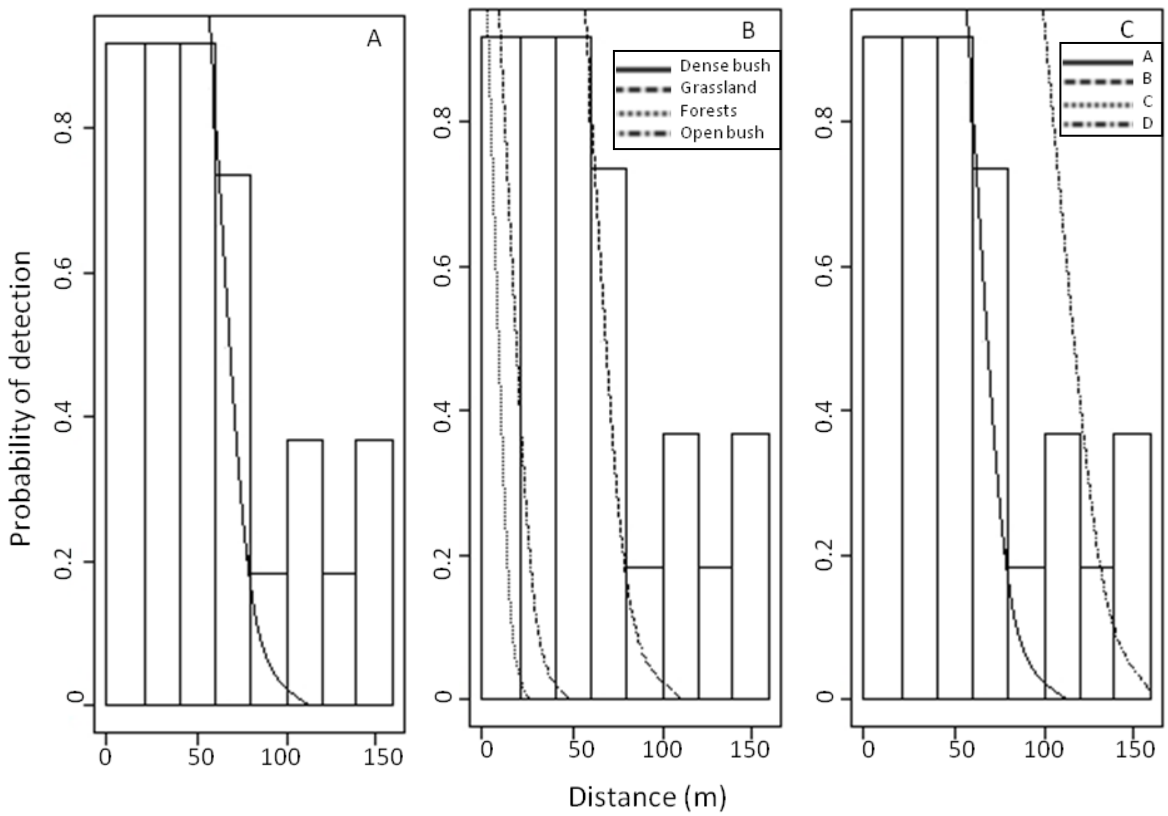

Figure 3.4. Mean half-normal function with cosine2 adjustment detection probabilities (A) for land cover (B) and host group preferences (C) for red-billed oxpeckers in Tembe Elephant Park, KwaZulu-Natal, South Africa. (See Table 3.2 for host group).

Appendix 3.1

Total number of host species and oxpeckers observed at Ithala Game Reserve and Tembe Elephant Park.

	Ithala Game Reserve			Tembe Elephant Park		
Host Species	Sum of host	Sum of oxpecker	Sum of observations	Sum of host	Sum of oxpecker	Sum of observations
Buffalo	0	0	0	149	28	4
Bushbuck	20	0	13	4	0	4
Cattle	83	3	2	0	0	0
Eland	22	12	6	0	0	0
Elephant	0	0	0	107	0	24
Giraffe	52	43	16	23	24	12
Hartebeest	7	0	5	0	0	0
Impala	966	4	91	548	11	90
Kudu	103	6	26	12	0	3
Nyala	3	0	1	878	8	208
Reedbuck	20	0	9	16	0	8
Rhino	10	14	4	3	6	2
Stationary object	0	5	6	0	0	3
Tsessebe	10	0	2	0	0	0
Warthog	130	3	37	22	0	11
Waterbuck	9	0	4	2	0	4
Wildebeest	722	2	70	12	0	2
Zebra	1048	39	99	8	0	2
Total	3205	131	391	1784	77	377

Appendix 3.2: Online Questionnaire: Information requested on red-billed oxpecker sightings

The red-billed oxpecker (*Buphagus erythrorhynchus*) is found in the bushveld and savanna regions of South Africa. They can be identified by their red bill, yellow wattle around the eye and a dark rump. These birds are typically seen perched on cattle and large game. Red-billed oxpecker populations suffered a decline resulting from a reduction of host species and the use of arsenic-containing dips. With the development of new chemical formulations for the control of ticks, which were non-lethal to the birds, the option of translocating them into suitable areas where they had disappeared, became a possibility.

A number of red-billed oxpecker translocations have taken place in South Africa at various farms and nature reserves initially by SANParks and later by the Endangered Wildlife Trust's Operation Oxpecker project. For her MSc project in the School of Life Sciences, University of KwaZulu-Natal (Pietermaritzburg campus), Maryna Jordaan is assessing how successful these translocations have been. We are requesting any observational information on red-billed oxpeckers in KZN. More specifically, where they have been seen and where they are nesting. Consequently, if you know of any red-billed oxpecker breeding sites in your area, or if you have these birds on your farm or game reserve etc., we would appreciate it if you could answer the following questions. Section A is an observer survey to account for any ambiguity in the questionnaire. Section B covers red-billed oxpecker sightings in your area. Section C is only for persons that manage farms or reserves or conservancies. Where applicable, you may tick more than one option in sections C and B.

Your participation in this project is voluntary. You may refuse to participate or withdraw from the project at any time with no negative consequence. There will be no monetary gain from participating in this survey. Your contribution to this project will be confidential and anonymous. Photographs of red-billed oxpeckers seen and the geographical location (GPS points) would also be valuable information. If you have any further questions for information, please contact Maryna Jordaan: rynamay@gmail.com or Prof Colleen Downs: downs@ukzn.ac.za or 033 260 5127 (w) or 082 920 2026 (c) at the School of Life Sciences, University of KwaZulu-Natal, Pietermaritzburg campus, Scottsville.

Section A: Observer survey

1. Race:
- ☐ Indian
- ☐ Caucasian
- ☐ African
- ☐ Coloured
- ☐ Other (Please specify):…………………………………………………………................

2. Sex:
- ☐ Male
- ☐ Female

3. Age:
- ☐ Under 20
- ☐ 20-29

- ☐ 30-39
- ☐ 40-49
- ☐ 50-59
- ☐ 60-over

4. Living environment:
- ☐ City or urban
- ☐ Rural community
- ☐ Farmland
- ☐ Other (Please specify):…………………….………………………………………….……................

5. Highest level of education:
- ☐ Less than a high school degree
- ☐ High school degree or equivalent (e.g. GED)
- ☐ Some college but no degree
- ☐ Bachelor degree
- ☐ Graduate degree
- ☐ Other (Please specify):………………………………………………………………...

6. What is your occupation?……………………………………………………………...

7. What town and province do you live in?...

………………………………………………………………………………………………

Section B: Red-billed oxpecker sightings in your area

1. What is the name of the nearest town to where you saw red-billed oxpeckers?

(If you have GPS co-ordinates of the sighting, please state them)

………………………………………………………………………………………………

2. Have red-billed oxpeckers always been in your area? (If oxpeckers were not always in your area, please state when you first noticed them)

………………………………………………………………………………………………

3. Where was your sighting of red-billed oxpeckers?
- ☐ Livestock Farm
- ☐ Game reserve
- ☐ Conservancy
- ☐ Other (Please specify) ……………………………………………………………………

4. How often do you usually see red-billed oxpeckers?
- ☐ Every day
- ☐ Once a week
- ☐ Once a month
- ☐ Other (Please specify):…...……………………………………………………………………

5. What time of day did you see red-billed oxpeckers?
- ☐ Before 9 am

- ☐ 9 am – 12 pm
- ☐ 12 pm – 3 pm
- ☐ 3 pm – 6 pm

6. How many red-billed oxpeckers did you see?
- ☐ Less than 10
- ☐ 11 – 20
- ☐ 21 – 30
- ☐ Other (Please specify):…………………………………………………………………

7. What is your perception of red-billed oxpeckers?
- ☐ Help with tick control on animals
- ☐ Pest, for example, causing damage to animals from wound feeding
- ☐ Other (Please specify): ……………………………………………………………..

Section C: Managers of farms, reserves or conservancies

1. Where is the property located (GPS coordinates)?

………………………………………………………………………………………………

2. What is the area that you manage?
- ☐ Cattle farm
- ☐ Game farm
- ☐ Game reserve
- ☐ Conservancy
- ☐ Other (Please specify):…………………………………………………………………

3. What is the largest herbivore on your property?

……..……………………………………………………………………………………..

4. How large is the property (hectares)?

………………………………………………………………………………………………

5. Do you use agrochemicals to control ticks? (If yes, please state the name of the product and if it is oxpecker friendly/not fatal to birds)

………………………………………………………………………………………………

6. Are there red-billed oxpeckers present on the property?
- ☐ Yes
- ☐ No
- ☐ Unknown

7. If yes, have red-billed oxpeckers always been on the property? (If no, please state when you first noticed them)

………………………………………………………………………………………………

8. How many red-billed oxpeckers did you see?
☐ Less than 10
☐ 11 – 20
☐ 21 – 30
☐ Other (Please specify):…………………………………………………………………...

9. How often do you see red-billed oxpeckers?
☐ Every day
☐ Once a week
☐ Once a month
☐ Other (Please specify):…………………………………………………………………...

10. Do they roost on the property?
☐ Yes
☐ No
☐ Unknown

11. Do they breed on the property?
☐ Yes
☐ No
☐ Unknown

12. What time of day do you regularly see red-billed oxpeckers?
☐ Before 9 am
☐ 9 am – 12 pm
☐ 12 pm – 3 pm
☐ 3 pm – 6 pm

13. Are there red-billed oxpeckers on neighboring farms/areas? (If yes, please specify what the area is)

………………………………………………………………………………………........................

14. What is your perception of red-billed oxpeckers?
☐ Help with tick control on animals
☐ Pest, for example, causing damage to animals from wound feeding
☐ Other (Please specify): ………………………………………………………………..

END

Thank you for your contribution

CHAPTER 4

Conclusions

There are numerous factors that contribute to a bird species becoming threatened and in need of increased conservation efforts in order to survive (Soorae & Seddon 2000). Conservation translocations aim to increase the survival of threatened species by reducing their rate of extinction, either for educational, scientific or for supportive purposes (Cromarty & Alderson 2013). Conservation translocations are defined as the "intentional movement and release of a living organism, where the primary objective is a conservation benefit: this will usually comprise improving the conservation status of the focal species locally or globally, and/or restoring natural ecosystem functions or processes". (IUCN/SSC 2013).

Research findings

There were 24 red-billed oxpecker translocations in South Africa since 1988 and 13 population reinforcements (Chapter 2). Reporting rates of red-billed oxpeckers significantly increased from SABAP1 to SABAP2 (Chapter 2). In South Africa, red-billed oxpeckers colonised several new areas, particularly areas surrounding previous occurrence where reporting rates increased (Chapter 2). There was a positive nett change in reporting rate at all release sites in South Africa (Chapter 2).

Important factors to consider translocating red-billed oxpeckers include the type of habitat, host species and host herd size (Chapter 3). Red-billed oxpeckers are more easily detected when they are feeding on hosts in open areas (Grobler 1979). Herbivores that form large herds, increase the probability of red-billed oxpeckers visiting them (Chapter 3). Although, larger sized hosts are generally more preferred by red-billed oxpeckers, we have observed these birds on smaller host herbivores (Hart *et al.* 1990) (Chapter 3). Smaller ungulates, such as Impala, have more ticks in the larval or nymph stages as opposed to ticks in the adult stage (Hart *et al.* 1990). Impala often form large herds that integrate with other larger host species, such as Zebra (Jarman 1978). Red-billed oxpeckers will opportunistically feed from smaller hosts when the time spent searching for food is low (Grobler 1980; Hart *et al.* 1990; Mooring & Mundy 1996; Mooring & Mundy 1996). Although red-billed oxpeckers are often seen on domesticated livestock, a land owner noted an increase in red-billed oxpeckers when he changed from livestock to game farming (Chapter 3). Consequently, the importance of a variety of hosts is indicated for maintaining populations of red-billed oxpeckers.

Discussion and recommendations for successful red-billed oxpecker translocations

Translocations of red-billed oxpeckers in South Africa have been implemented over 26 years. The Operation Oxpecker Project monitors the survival of the birds through colour ringing and a reporting scheme, involving the management teams of the release areas, field staff, volunteers and tourists. This programme also employs the use of soft-releases which are thought to have higher post-release survival rates then hard-releases as found in other studies (Teixeira *et al.* 2007). Red-billed oxpeckers successfully bred at translocated sites where soft releases occurred (Chapters 2 and 3). In addition, the natural dispersal of red-billed oxpeckers has not had any negative effect on their population at release sites (Chapter 3).

It is important to maintain a suitable habitat that is protected for the species that is to be translocated (Griffith *et al.* 1989; Wolf *et al.* 1998). The ecological requirements of the species that is to be translocated needs to be determined (Hunter 1998). All sites where red-billed oxpeckers were translocated had suitable habitats and were protected (Chapter 2). The number of release events and the number of individuals per release are important to consider, as it is correlated with a higher chance of translocation success (Griffith *et al.* 1989; Hopper & Roush 1993; Wolf *et al.* 1998; Deredec & Courchamp 2007). In most cases, the more individual birds that are released together the more successful are they than those that are released in small groups (Brightsmith *et al.* 2005). Although only six out of the 24 release sites received more than 80 red-billed oxpeckers, it is clear from the nett reporting rate changes that releasing more birds into an area did not equate to a higher nett positive change in reporting rate (Chapter 2).

The placement of nest boxes at the release sites is an essential component of the programme, in order to promote breeding in their new site (Chapter 2). This serves the added benefit of being able to monitor the reproductive success of the birds through monitoring all activities at the nest boxes. The feedback received on sightings of the birds provides a further method of measuring reproductive success in these reintroductions, as all juveniles or adults without colour and metal rings can be considered progeny of the released individuals.

Future work

Translocation projects will never be able to improve strategies if post-release monitoring programmes are insufficient or ineffective (Ewen & Armstrong 2007). Sutherland *et al.* (2010) provided suggestions for ways to monitor bird reintroductions. These included estimating population changes using birth and death rates, documenting breeding (either through monitoring nests, finding juveniles or a colour-ringing scheme where all non-ringed birds indicate successful breeding or dispersal events) or through recording presence/absence and changes in population abundance (Sutherland *et al.* 2010). Although our study has addressed some of these criteria, detailed population estimates for release sites would further substantiate our results. We suggest that any future reintroductions of red-billed oxpeckers contain a detailed post-release monitoring plan that addresses which of the above-mentioned methods will be used to determine the success of the reintroduction.

There was a low percentage of red-billed oxpeckers detected in IGR and TEP. Based on our observations, red-billed oxpeckers were best detected when they were calling. These birds have no striking colours and were difficult to detect when they were silent. We suggest that transect surveys should be done until the percentage of red-billed oxpeckers detected is higher. In addition, future surveys should consider including management roads to increase the area surveyed and not just roads accessible to tourists. As this research was conducted during the breeding season (summer) of red-billed oxpeckers, additional population surveys should be done to determine whether there is a seasonal effect on red-billed oxpecker populations. Results from genetic and isotope data collected in the current study are still pending and will contribute further to understanding the success of translocated red-billed oxpeckers.

Concluding remarks

There are several benefits to translocating native species, for example, translocations assume that by releasing a species into a suitable habitat, it may be restored to its natural state (Seddon 1999). At the new site, translocated birds may increase the biodiversity and/or create public support to restore and protect the habitat (Seddon 1999). Red-billed oxpeckers provide an increasingly beneficial service of reducing the tick-load on herbivores.

Only when the population is self-sustaining, with released individuals successfully breeding, and does not require further intervention, is a translocation considered successful (Griffith *et al.* 1989; Dodd & Siegel 1991; IUCN 1998; Seddon 1999). Based on this definition, we have determined that red-billed oxpecker translocations have been successful particularly in KZN. Red-billed oxpeckers bred successfully in IGR and TEP and this was confirmed as we caught red-billed oxpeckers that were breeding, as determined by the presence of a brood patch, as well as juvenile oxpeckers. In addition, we observed adult red-billed oxpeckers mating and collecting nesting material, and juveniles feeding from hosts in family groups. Red-billed oxpeckers are naturally dispersing and increasing their range from their release sites. This was confirmed from landowners reporting the first time they had been observed on their properties.

By using bird atlasing data, it is clear that red-billed oxpeckers have expanded their range in the past 20-30 years in South Africa (Loftie-Eaton 2015). Red-billed oxpeckers were until recently listed as *Near Threatened* in South Africa (Craig 2005). As a result of their increased distribution range, the species has been down-listed to *Least Concern* (Taylor *et al.* 2015). Our results show that translocation has been an effective conservation tool for the species' persistence.

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