WILDLIFE REHABILITATION

IN

SOUTH AFRICA

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ABSTRACT

Wildlife rehabilitation, defined as “providing temporary care to injured, ill and orphaned wild animals with the goal of releasing them back into their natural habitat”, developed in response to the increase in human population and urbanisation. Widllife rehabilitation centres developed to deal with casualties from man-made hazards; and because rehabilitation involves human emotions of empathy and compassion, the activity has not tended to be the domain of wildlife specialists, but of concerned members of the public. This has caused concerns for wildlife specialists over the welfare of animals being rehabilitated, because making decisions based on emotions may result in an animal being kept alive under unethical conditions, instead of being euthansed. Furthermore, there may be negative impacts on conservation, as it could divert money away from habitat protection and may place wild populations at risk from disease and genetic pollution. This dichotomy in opinion is most often seen between rehabilitators, who focus on the individual animal, and government wildlife officials, who grant them permits, and who focus on the security of entire communities.

Although the value of wildlife rehabilitation cannot be underestimated, in terms of its service to wildlife and the public, there is a need to evaluate whether wildlife rehabilitation may result in more rather than less animal suffering and have a detrimental impact on the existing wild populations. I thus set out to determine the efficacy of wildlife rehabilitation, particularly in South Africa. In the first assessment of rehabilitation centres in South Africa, 65% known centres (n = 63) from all nine provinces returned questionnaires. Several thousand injured, diseased and orphaned animals pass through these centres each year, clearly showing the need for rehabilitation centres in South Africa. However, due to lack of scientific research on the efficacy of rehabilitation methods of care and release, and minimal post-release monitoring, I found that experience and intuition drove most rehabilitation practices. Additionally, because personnel from most centres cited lack of finance as a main impediment to the goal of rehabilitation, the result of rehabilitation may include negative affects on individual animal welfare and survival, as well as on conservation efforts for wildlife communities. Thus, I suggested wildlife rehabilitation be centralised to a provincial or national government. Furthermore, I suggested that guidelines of minimum standards should be developed in consultation with experienced rehabilitators, veterinarians and conservation scientists; to be enforced by trained and dedicated conservation officials.

To gain further insight into the need for wildlife rehabilitation in a community in South Africa, I decided to examine four-years of intake records from a large rehabilitation centre in the KwaZulu-Natal Province for trends. Animal intake rate was high (2701 ± 94 per annum). Most of the intake (90%) was birds, with few mammals (8%) and reptiles (2%), and most of these were of locally common species (eg doves, pigeons). This reflects the findings of other studies, namely that species living in close association with humans are the most frequently admitted to rehabilitation centres. In total, most of the animals admitted (43%) were juveniles, which were assumed to be abandoned or orphaned. The implications of then rehabilitating these juveniles, which were largely uninjured, is whether humans should be interfering with nature if the cause was not human-related; can each juvenile (especially in these large numbers) be adequately prepared to survive and thrive when released into the wild; and is there space in the environment for them, without causing harm to others already in the environment. I suggest that the large numbers of animals currently being admitted to the centre may be reduced, possibly through increased public education particularly to leave uninjured juveniles in the wild. Furthermore, improvements in the centre's recording system may allow for use in funding requests and for various research opportunities.

There is a general lack of post-release monitoring in wildlife rehabilitation, and the IUCN advises that confiscated and orphaned animals should be euthanased or placed in life-time captivity. I thus decided to document the post-release fate of rehabilitated vervet monkeys and leopard tortoises, two species commonly admitted to a rehabilitation centre, and rock hyrax (*Procavia capensis*), as a further case study, even though individuals were not from a rehabilitation centre. Success of releasing rehabilitated animals cannot be judged on whether it results in a self-sustaining population, as in reintroductions, as it is to improve the welfare of that particular animal, independent of its species' status. Survival is thus the most basic indicator of a successful rehabilitation release. Other aspects, such as behaving similarly to a wild animal, are additional success factors, as they likely influence survival. Although after one year post-release, the two troops (T1 = 35, T2 = 24) of vervet monkeys (including an infant) survived, were independent of human food provision and companionship, had established in an area, and had births in the breeding season following release; low known survival (T1 = 11%, T2 = 50%) make it difficult to designate these releases as successful. However, it was clear that the two groups of rock hyrax released were not successful. The group of rock hyrax that had previously been in captivity for 16 months (n = 17) did not have site fidelity after release, and after three months could not be found. All wild rock hyrax (n = 9), except one whose fate is unknown, were found dead, mostly predated, within 18 days. The release likely failed due to predation. For both vervet monkeys and rock hyrax, a lack of social cohesion was suggested as causing the group to dissolve or split upon release, which in turn would increase their vulnerability to predation. Recommendations are provided for considerations in future releases of captive vervet monkeys and rock hyrax.

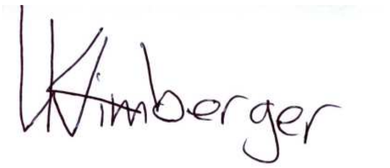
Movements of two groups of tortoises (ten and seven individuals) released at two different sites were monitored over a year, using radio-telemetry. In total, one tortoise was returned to captivity because of disease, four were killed intentionally or accidentally by humans, three others died due to a combination of disease, starvation and/or dehydration, and the fate of six were unknown. Since only two out of seven tortoises survived 13 months after release and only one out of ten tortoises were known to have survived 25 months after release, rehabilitated leopard tortoises were not successfully released into the wild. Recommendations to improve the success of future releases are provided. The occurrence of disease in the tortoise release was a worrying result, and must be addressed before any further releases are allowed.

To summarise, there is a dichotomy between wildlife rehabilitation and conservation throughout the world, but this study highlighted the situation in South Africa. The IUCN guidelines for the reintroduction, introduction and supplementation of animals make it clear that there are many threats to the individual animal, to the release environment and to the conservation of species when transporting and releasing animals, especially if they had been in captivity. I believe that I have presented enough evidence in the thesis to suggest that wildlife rehabilitation may result in negative consequences to the welfare of the individual being rehabilitated and to the wild conspecifics or to other species in the release site. I suggest that wildlife rehabilitation needs to move away from being an emotional-based “animal-rights” organisation, to being objectively managed, such that no harm is caused to conservation by these efforts. This may require them to change their constitution so they are aligned with the IUCN guidelines, where more consideration is given to the possible risks involved in releasing animals. However, the applicability of the IUCN guidelines will vary slightly according to the species and situation, and they require input from the local conservation authorities (as was the case in the studies documented in this thesis). I suggest that the public be educated as to the risks that wildlife rehabilitated animals can pose to the safety of the environment as a whole, and that rehabilitated animals do not necessarily survive or thrive in the wild when released, and thus they have to understand that rehabilitation centres will sometimes have to prioritise casualties for treatment, and euthanase exotic species. In conclusion, implementing further research in ensuring long-term post-release survival of rehabilitated animals; developing and enforcing practical guidelines/minimum standards by dedicated and qualified governmental wildlife conservation officials; and having examinations in order to qualify as a wildlife rehabilitator, will ensure humans are “making amends” instead of having an additional negative impact on conservation and animal welfare.

PREFACE

The data described in this thesis were collected in the Republic of South Africa from August 2006 to December 2008. Experimental work was carried out while registered at the School of Biological and Conservation Sciences, University of KwaZulu-Natal, Pietermaritzburg, under the supervision of Professor Colleen T. Downs and co-supervision of Professor Michael R. Perrin.

This thesis, submitted for the degree of Doctor of Philosophy in the Faculty of Science and Agriculture, University of KwaZulu-Natal, Pietermaritzburg, 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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Kirsten Wimberger

May 2009

I certify that the above statement is correct…

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Professor Colleen T. Downs

Supervisor

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DECLARATION 1 - PLAGIARISM

I, Kirsten Wimberger, declare that

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2. This thesis has not been submitted for any degree or examination at any other university.

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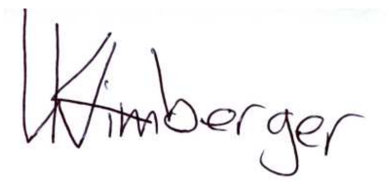

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DECLARATION 2 - PUBLICATIONS

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

Publication 1

K Wimberger, CT Downs and RS Boyes. A survey of wildlife rehabilitation in South Africa: is there a need for improved management?

Author contributions:

KW conceived paper with CTD. KW collected and analysed data, and wrote paper. CTD and RSB contributed valuable comments to the manuscript.

Publication 2

K Wimberger and CT Downs. Annual intake trends of a large urban animal rehabilitation centre in South Africa: a case study

Author contributions:

KW conceived paper with CTD. KW collected and analysed data, and wrote paper. CTD contributed valuable comments to the manuscript.

Publication 3

K Wimberger, CT Downs and MR Perrin. Post-Release Success of Two Rehabilitated Vervet Monkey (*Cercopithecus aethiops pygerythrus*) Troops in KwaZulu-Natal, South Africa

Author contributions:

KW conceived paper with CTD and MRP. KW collected and analysed data, and wrote paper. CTD and MRP contributed valuable comments to the manuscript.

Publication 4

K Wimberger, CT Downs and MR Perrin. Two unsuccessful re-introduction attempts of rock hyrax (*Procavia capensis*) into a reserve in the KwaZulu-Natal Province, South Africa

Author contributions:

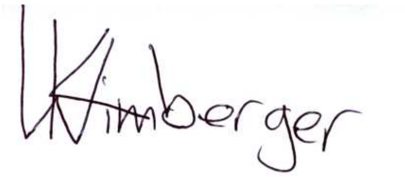
KW conceived paper with CTD and MRP. KW collected and analysed data, and wrote paper. CTD and MRP contributed valuable comments to the manuscript.

Publication 5

K Wimberger, AJ Armstrong and CT Downs. Can rehabilitated leopard tortoises, *Stigmochelys pardalis*, be successfully released into the wild?

Author contributions:

KW conceived paper with CTD and AJA. KW collected and analysed data, and wrote paper. CTD and AJA contributed valuable comments to the manuscript.



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Kirsten Wimberger

May 2009

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I am grateful to my parents, who allowed me to pursue my dream in "becoming a zoologist", with all the support I needed, be it emotional or financially. Thank you for inspiring me with your own interests in wildlife and welfare, and in the belief that anything is possible if you work at it.

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A note to myself in future endeavours: “Hindsight is crystal clear”.

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CHAPTER 1

Introduction

REVIEW OF WILDLIFE REHABILITATION IN THE CONTEXT OF CONSERVATION BIOLOGY

Background

Since the industrial revolution, human populations have grown exponentially around the world (Meffe & Carroll 1997). The associated agricultural expansion, consumption, land conversion and development have had a negative impact on natural ecological systems, resulting in a significant rise in anthropogenic species extinctions (Meffe & Carroll 1997). The present mass extinction will likely be greater than any other in the past, if no action is taken (Şengőr et al. 2008). The field of conservation biology was developed in response to this global biodiversity crisis (Meffe & Carroll 1997). Its aim is to conserve biodiversity, namely species and ecosystems (Rolston 1997), either for its intrinsic value, or its value as a natural resource (e.g. food, medicine), a service (e.g. recycling plant nutrients, cleaning water), an information system (e.g. genetic engineering), and for spiritual reasons (Callicott 1997). The necessary management interventions to ensure long-term survival of species in the wild are either by protecting the natural habitat for the species to exist (MacKinnon & MacKinnon 1991), or using translocations to conserve species. These translocations are called re-introductions, when attempts are made to establish a species where it has become extirpated or extinct; re-enforcements, when individuals are added to a declining population; or introductions, when attempts are made to establish a species outside its native range (International Union for Conservation of Nature and Natural Resources (IUCN) 1998, 2000). Translocation will be the term used to describe any of the above deliberate movements of animals (IUCN 1998), excluding a "rescue/welfare release".

Wildlife rehabilitation is defined as "providing temporary care to injured, ill and orphaned wild animals with the goal of releasing them back into their natural habitat" (Anon 2008a). It is mentioned in the context of conservation biology, as it also developed in response to the increase in human population and urbanisation. However, because its objective is to "conserve" the individual animal for its intrinsic value, where individuals are released for improvement of its welfare ("rescue/welfare release") (Baker 2002), there may be conflict with conservation priorities. Urbanisation has lead to a decrease in biodiversity with the loss and fragmentation of suitable habitat (McKinney 2002; Baker & Harris 2007), but it has also lead to an increased abundance of species that are able to adapt to the man-made-landscape (Bradley & Altizer 2006). Consequently there is an increase in human-wildlife conflict (Kretser et al. 2008; Hubbard & Nielsen 2009), such as deer-induced vehicle collisions (Messmer 2009), with a corresponding increase in injured animals. Therefore, wildlife rehabilitation involves the rescue of animals that are in the particular predicament largely as a result of man-made hazards (Trendler 1995a; Jacobs 1998). Rehabilitation enables humans to "make amends" (Aitken 2004, p 136) by offsetting man's negative impact on wildlife, and involves feelings of compassion (Holcomb 1995) and empathy (Lloyd 1999).

Wildlife rehabilitation is thus not usually the domain of wildlife specialists, but of concerned members of the public (Dubois 2003). This has caused concerns for wildlife specialists over the welfare of animals being rehabilitated, because making decisions based on emotions can result in inexpert care and/or an animal being kept alive under unethical conditions, instead of being euthanased (Curtis & Jenkins 2002). Furthermore, there is concern over the possible negative impact on conservation, as it could divert money away from habitat protection (as reviewed by Kirkwood 1992; Soorae 2005), and when animals are released it may place wild populations at risk from disease and genetic pollution (as reviewed by IUCN 2000, Measures 2004 and Soorae 2005). The rehabilitation of animals that are diseased or injured through natural causes could result in evolutionary less-fit individuals being released back into the environment (Kirkwood & Best 1998), and this could meddle with host-parasite coevolution (Moore et al. 2007). If these possibilities turn out to be real, there would likely be negative impacts on conservation efforts. However, others believe that rehabilitation contributes to conservation (as reviewed by Kirkwood 1992; Trendler 1995b) if the species is endangered (Measures 2004) or in general, by increasing the public's capacity to care for wildlife (Aitken 2004). It also offers an opportunity to gain insight into diseases and threats affecting wild animal populations (Measures 2004). Furthermore, the impact on wild populations of releasing rehabilitated animals into the wild is generally not thought to be of any consequence, because of the small, localised releases (Moore et al. 2007). However, this belief may need amending (Moore et al. 2007), because of the 1000's of animals admitted annually to and released from centres located throughout the world; the knowledge that in the past some animal translocations (especially introductions) have had a negative impact on the environment; and because there is limited research available to suggest that the release of rehabilitated animals does not have a negative impact. There is, thus, a need to determine the efficacy of wildlife rehabilitation, within a context of maximising animal welfare and minimising possible negative consequences to conservation.

Rehabilitation centres and record keeping

Worldwide there are thousands of wild animal rehabilitation centres, for instance, there are at least 5000 registered rehabilitators in the United States of America (USA) (Jacobs 1998), and 650 - 800 in the United Kingdom (UK) (Kelly & Bland 2006; Leighton et al. 2008). Some are specialised, such as the 65 birds of prey centres in Spain (Fajardo et al.

2000), and about 100 centres in 16 countries only dealing with marine mammals (Measures 2004). The few published inventories of these centres indicate the large number of animals brought for rehabilitation, where in Canada 11 facilities accepted nearly 30 000 animals of 276 species over 11 years (Dubois 2003), while in England, four facilities accepted over 5000 birds and mammals (each from only four species) over four years (Molony et al. 2007). Analyses of records from these centres have shown that animals are brought to rehabilitation centres for a variety of reasons, but the main causes are generally orphaned/abandoned, cat (*Felis catus*) attack and vehicle impact (Hartup 1996; Kirkwood & Best 1998; Dubois 2003; Kelly & Bland 2006).

Besides identifying the threats to wildlife, analysis of records from rehabilitation centres may be used practically in conservation and rehabilitation. For instance, areas where animals frequently encounter harm ("hot spots") can be identified (Curtis & Jenkins 2002; Harden et al. 2006; Drake & Fraser 2008). Nature conservation government officials and wildlife researchers can then use this information to place preventative measures at these sites (Drake & Fraser 2008). Records can also be used to monitor diseases affecting wild animals (Kirkwood 1992; Measures 2004). Furthermore, studies have shown that records can be used to identify individuals that are high-risk, so that special care is provided to these individuals (e.g. ducklings with low body mass, Drake & Fraser 2008). These tools have been under-utilised and possibly the reason for records generally being incomplete (e.g. in Italy: Fajardo et al. 2000, Canada: Dubois & Fraser 2003, USA: Kelly & Sleeman 2003, Harden et al. 2006). However, records should be analysed by the rehabilitation centres themselves to learn from their successes and failures (Trendler 1995b), such as determining whether the changes they made to their rehabilitation methods had an improvement on release rates (Parsons & Underhill 2005). This is an important avenue of concern, as generally out of those admitted, less than half survive to be released

(Dubois 2003; Molony et al. 2007). Release rates from a centre are often used to determine the success of wildlife rehabilitation (Dubois & Fraser 2003). Success has also been assessed on whether the centre has increased the public awareness of animal welfare issues (Kirkwood 1992; Dubois & Fraser 2003; Aitken 2004). However, these criteria should be seen as additional to determining whether the release of a rehabilitated animal was a success.

Defining success

Determining the success of a translocation depends on the goals of the project (Kleiman 1989; Fischer & Lindenmayer 2000). For most translocations, success is defined as the establishment of a self-sustaining population (Dodd & Siegel 1991; IUCN 1998), obtained by the survival and breeding of the released individuals, and persistence of this population (Seddon 1999). The duration over which this persistence is assessed is controversial, and some say it is dependent on each species' lifespan (Dodd & Siegel 1991), while others state that it is when the population has grown to 500 individuals (Beck et al. 1994). Regardless, the success of wildlife rehabilitation cannot be assessed in the same way as with these above translocations, as its main goal is to release previously injured, orphaned and/or ill individuals back into the wild (Anon 2008a). Survival must therefore be the most basic indicator of a successful rehabilitation release, because an ill-prepared animal would likely die soon after release, as a result of a decrease in condition (Waples & Stagoll 1997), or vulnerability to predation (Beringer et al. 2004). A contrary view is that any survival is seen as success, as these individuals would not have been alive were it not for the rehabilitation process (Reeve 1998). However, as a result of animals in rehabilitation centres having to go through the stress and fear of captivity and possible pain of healing (BWRC 1989 in Kirkwood 1992), it is imperative that this animal be at no greater disadvantage to living in the wild than its wild conspecifics of similar age, gender and status (IAAWS 1992), i.e. they should survive for a similar length of time (IUCN 2000; Goldsworthy et al. 2000; Molony et al. 2006). This may not seem realistic, and so others have suggested that survival of injured, ill or orphaned animals that have undergone rehabilitation should be compared with those in the same predicament but have not been rehabilitated (Aitken 2004). The latter does have merit, but this opinion may result in complacency. It is important, therefore, to compare survival to that of wild conspecifics, and that the cause of any deaths should be natural. For instance, an animal that died from starvation would be a failure, while this would not necessarily be the case if an animal died from predation. Additional criteria for success include if the released individuals integrate socially with the resident wild population (Waples & Stagoll 1997), behave similarly to a wild animal (Box 1991), and survive without human aid or comfort (excluding the duration of a soft release) (Cheyne & Brulé 2004; Grundmann 2005; Nicholson et al. 2007). However, these should only be seen as additional criteria to the first criteria of survival post-release. Post-release monitoring is thus the most important method to assess success of releasing a rehabilitated animal into the wild.

Post-release monitoring

Post-release monitoring is the only method to determine whether the release was successful (IUCN 1998) and whether the release resulted in any negative consequences to wild species in the release environment, such as having a negative impact on the food resources of wild conspecifics (Caldecott & Kavanagh 1983). However, it is generally lacking (Griffith et al. 1993; Kleiman 1996); or inefficiently done in many translocations (Fischer & Lindenmayer 2000). This is particularly true for rescue/welfare releases; for example, only 10 of 42 (24%) rehabilitation centres in Spain did any post-release assessment

(Fajardo et al. 2000). The low incidence of post-release monitoring of rehabilitated animals may be a consequence of it being a low funding priority for centres (Kirkwood & Sainsbury 1996; Lloyd 1999, Dubois & Fraser 2003), as most of the funding is spent on food for animals, housing, medication, and veterinary care (Trendler 1995c; Jacobs 1998), as well as on staff salaries (Kunz 1995). These expenditures are necessary to run a rehabilitation centre, and as most funding is often from the rehabilitators' own money (Jacobs 1998), priorities have to be made. Regardless, it is important that funding and resources be obtained for post-release monitoring, as a means of determining whether the release of a rehabilitated animal was successful.

Relatively few researchers have monitored post-release success of rehabilitated wild animals or published results in peer-reviewed journals (n = 76, 1979-2009: Table 1). In comparison, there have been 145 translocations (reintroductions using captive-bred animals) carried out during 1900-1994 (Beck et al. 1994), and 180 translocations (using captive-bred and wild animals) during 1979-1998 (Fischer & Lindenmayer 2000). Where success has been documented, most translocations of wild and captive-bred animals, and releases of rehabilitated animals have been in developed, temperate countries (79%: Beck et al. 1994; 75%: Fischer & Lindenmayer 2000; 68%: Table 1), very likely as a result of organisations there being better funded and staffed than developing countries (Beck et al. 1994). These translocations have also mainly involved birds (45%: Beck et al. 1994; 44%: Fischer & Lindenmayer 2000; 33%: Table 1) and mammals (32%; 50% and 61% respectively), while comparatively few involved other animal taxa. Furthermore, translocations usually involved four avian orders, namely Anseriformes, Falconiformes, Gruiformes and Galliformes, or two mammalian orders, the Artiodactyla and Carnivora (Seddon et al. 2005). This bias in taxa is not related to global conservation status of species, but to whether the species is charismatic (mammals, birds) and useful (especially game birds) (Seddon et al. 2005). This has been suggested as a way in which to gain public support for conservation (Seddon et al. 2005). Conversely, for rescue/welfare releases, the species is likely chosen as a result of public involvement or knowledge of the rescue process, especially seabirds (i.e. Charadriiformes, Ciconiiformes) rehabilitated after oiling, or sea-mammals stranding on the beach (i.e. Pinnipedia, Cetacea, Sirenia) (Table 1). However, the predominance of raptors (i.e. Falconiformes, Strigiformes) and primates, and comparatively little on rehabilitated reptiles, shows that most studies involve species that people find fascinating, such as a top predator, and those that are appealing and attractive (Table 1).

In addition to this taxonomic bias, there have been some scientific shortcomings of the post-release studies on rehabilitated animals. These include insufficient monitoring (e.g. Borner 1985); estimation of survival using ring recoveries (e.g. Barham et al. 2006); radio-transmitters falling off or failing resulting in animals having undetermined fates (e.g. Clark et al. 2002) or the study having to end prematurely (e.g. Stewart et al. 2001); short monitoring duration (e.g. eight weeks, European hedgehog *Erinaceus europaeus*: Molony et al. 2006); and small sample sizes (e.g. one individual: Lima et al. 2005) (Table 1). Nevertheless, these studies have shown that released animals are vulnerable to dying from starvation (e.g. Beck et al. 1991; Csermely 2000; Fajardo et al. 2000); accidents, such as electrocution (e.g. Csermely & Corona 1994), drowning (e.g. Morris et al. 1993; Goossens et al. 2005), vehicle impact (e.g. Roberston & Harris 1995; Leighton et al. 2008) and field mower impact (e.g. Lee 2004); disease (e.g. Hannah 1986, in Hannah & McGrew 1991; Cook 2004); attacks by wild conspecifics (e.g. Hannah 1986, in Hannah & McGrew 1991; Goossens et al. 2005); and predation (e.g. Augee et al. 1996; Lunney et al. 2004, Leighton et al. 2008). The latter is possibly because of a lack of learnt predator avoidance in orphaned young (e.g. Reeve 1998; Beringer et al. 2004). Additional problems encountered include individuals that flee (e.g. Goossens et al. 2005) or disperse widely (e.g. Cook 2004) from the release site, as this increased their chance of encountering harm (Hester et al. 2008); and individuals that are human-imprinted, which seek out human companionship (e.g. Yeager 1997; Beringer et al. 2004). Known survival of rehabilitated animals has thus generally been low, particularly when orphaned animals are released. For example, only 25% of 12 European hedgehogs released survived after 15 weeks (Reeve 1998) and none of the seven bats, *Pipistrellus sp.*, released in two groups and hand-reared under different protocols, survived after three days (Kelly et al. 2008). However, in the same study, when another five bats were released after similar pre-release flight training as in one of the previous groups, but done in a larger flight cage, they all were known to have survived between 5 - 10 nights (Kelly et al. 2008). Other projects that have also involved lengthy pre-release training (e.g. taught how to forage) and intensive post-release support have had higher survival. For instance, after 11 years spent on an island before release and veterinary treatment of injured animals post-release, 62% of 37 released chimpanzees, *Pan troglodytes*, survived eight years (Goossens et al. 2005). Similarly, translocations that released captive-bred animals were more successful if they used pre-release training than those that did not (Beck et al. 1994). Translocations were also more successful if they involved individuals from the wild rather than captive-bred, if large numbers of individuals were released (e.g. $n > 100$ more successful) (Griffith et al. 1989; Fischer & Lindenmayer 2000), the original cause of decline was removed (Fischer & Lindenmayer 2000); the release was within historical range and into good quality habitat (Griffith et al. 1989). Conversely, translocation failure has resulted from high mortality due to predation (Griffin et al. 2000), and individuals returning to their former home range (Harthoorn 1962; Fischer & Lindenmayer 2000). These reasons are likely relevant to the failure or success of rescue/welfare releases, which implies that practitioners involved in these releases could learn from practitioners involved in translocations for other reasons (e.g. conservation), and visa versa. Furthermore, this means that the risk of translocations having a negative impact on the welfare of the individual being translocated and/or to the environment is also likely to apply to rescue/welfare releases.

Risks of release and IUCN guidelines

The two most significant risks of a translocation are that individuals introduce foreign parasites and foreign (or even modified: Moore et al. 2007) diseases (Chivers 1991; Viggers et al. 1993; Cunningham 1996; IUCN 1998); and interfere with the genetic composition of wild conspecifics (Griffiths et al. 1996; Hodder & Bullock 1997). Disease not only affects an animal's immune system, making it vulnerable to other infections, but could also make it susceptible to predators and other ecological determinants of competitive fitness (Measures 2004). While in captivity, animals can contract diseases from conspecifics, other species and even humans (Woodford & Kock 1991; Kirkwood & Best 1998; Steele et al. 2005). The chance of contracting a disease in captivity is relatively great, because animals are in close proximity to each other (Griffith et al. 1993; Moore et al. 2007), and under stress (Woodford & Kock 1991). The lack of pre-release disease checks before releasing rehabilitated animals has been cited as potentially important factor in which wild animals can become infected (Woodford & Rossiter 1994), which could have an impact on wildlife conservation.

There are other potentially negative consequences of translocating animals. Translocated individuals may have a negative impact on food resources and behaviour of wild conspecifics (Caldecott & Kavanagh 1983; Yeager 1997), and interfere with the ecology of the release habitat (Conant 1988), especially if carrying capacity is reached (Brambell 1977). There are also risks to the animal being released, particularly if they are captive-born (or captive-raised), as they may not know how to forage or avoid predators effectively (Brambell 1977; Beck et al. 1991; Kleiman 1996). These concerns are applicable to wildlife rehabilitation, as rehabilitated animals are often released into areas where wild conspecifics already occur, and it is common for orphaned/abandoned juveniles to be hand-raised and released.

The IUCN developed guidelines for the translocation and release of living organisms in an attempt to minimise negative consequences (IUCN 1998, 2000; Baker 2002). These suggest that preparations for release must include the following: ensuring individuals selected for release are disease free, in good health, genetically related to conspecifics in area, and are adequately prepared/trained for life in the wild (especially if captive-bred) (IUCN 1998, 2000). Furthermore, individuals should be released into a suitable habitat within the historical range of the species, the previous cause of decline must be eliminated and the release may need to be supportive (e.g. holding cage and supplementary feeding) (Brambell 1977; Kleiman 1989; IUCN 1998, 2000). There are no specific guidelines for rescue/welfare releases, but since the IUCN has developed guidelines for the placement of confiscated animals (IUCN 2000) to maximise welfare of animal released and to minimise negative consequences of the release on the environment, these guidelines seem to be suitable to use as a benchmark for evaluating the placement options of rehabilitated animals. It must be appreciated that these are only guidelines, and its applicability will vary slightly according to the species and situation, and they require input from the local conservation authorities (as was the case in the studies documented in this thesis). These guidelines advise that life-long care in captivity or euthanasia may be more suitable options for confiscated animals (IUCN 2000), because the "conservation of the species as a whole, and of other animals already living free, must take precedent over the welfare of individual animals that are already in captivity" (IUCN 2000, p12; Baker

2002, p8). This is an expansion of the precautionary principle, which states that caution must be taken with human actions on the environment if there is a lack of scientific knowledge of the effect, but there is a strong possibility of it causing significant harm (Myers 1993). Wildlife rehabilitation, particularly the release of rehabilitated animals, has generally ignored this principle, and this is a cause for concern. Although an absolute belief in the principle is not called for, it is necessary to move away from the often narrow focus of wildlife rehabilitation on the welfare and survival of the individual, and the benefits of this practice, to a view that examines whether wildlife rehabilitation does any harm to the welfare and survival of individuals already existing in the environment, and examine the possible negative consequences to the conservation of wildlife communities.

MOTIVATION FOR THE STUDY

Wildlife rehabilitation helps wild animals that are in distress or injured. This means that wild animals are taken out of their natural environment and are either humanely euthanased, or remain in captivity until their injuries heal, their health is improved or if an orphan, until it is old enough to survive on its own when released into the wild. Rehabilitation centres also provide a place for ex-pets and confiscated animals to learn the skills needed for release into the wild. For these reasons, I believe that there is a need for rehabilitation centres, especially as most of the injuries to wild animals are as a result of humans. In this regard, rehabilitation centres also provide a service to the community, as a person now feels that there is a place where an injured, ill or orphaned wild animal that he or she finds can be helped, which brings satisfaction to the person.

I do not question the positive role of wildlife rehabilitation or even their existence, and I value the work that they do. However, what I do question is whether there has been enough thought or research on whether this practice has a negative impact on the conspecifics or other species already existing in the environment in which a rehabilitated animal is released. Given the dire situation that conservation scientists face today, mainly caused by humans and their changes to the environment, it is important that rehabilitation is not adding to the problem. Furthermore, since wildlife rehabilitation is often done by inexperienced and unqualified animal care professionals (i.e. not veterinarians, veterinary nurses or people trained in wildlife care), I also question whether the welfare of animals undergoing rehabilitation is not being compromised, such that wildlife rehabilitators are doing more harm than good. I believe that this thesis is not only important for scientists involved in conservation and welfare, but also for the pubic, as most people donate money to wildlife rehabilitation centres with the expectation that people are qualified to rehabilitate wild animals, and that the rehabilitated animals survive after being released.

I, therefore, set out in my thesis to question the efficacy of wildlife rehabilitation and its potential negative effects on conservation and animal welfare, particularly in South Africa. There is scant data on the success or failure of wildlife rehabilitation practices in this country. It is an ideal time for this study, as the situation here is one of renewed interest in wildlife rehabilitation by the public, government and academics, after a long period of it being largely ignored. Wildlife rehabilitation in South Africa goes back to the 1950s, when it was started by nature conservation agencies (Carr 1995). By the late 1980s rehabilitation became a low priority for conservation and so it moved into the private sector (Carr 1995). A few years later the first wildlife rehabilitation conference was held, where minimum standards for care (Trendler 1995b) and release (Verdoorn 1995) were presented, as well as plans to form a “Rehabilitation Council” (Lockwood 1995, p35). This has been the only national rehabilitation conference, and to date nothing has come to fruition, until recently. The conservation authority Ezemvelo KZN Wildlife (EKZNW) has developed three documents pertaining to wildlife rehabilitation, namely Ex Situ Wild

Animal Management Policy, Norms and Standards for Care and Management of Ex Situ Vervet Monkeys *Cercopithecus aethiops* in KwaZulu-Natal, and Norms and Standards for the Management of Primates in KwaZulu-Natal. The Board of EKZNW recently adopted the latter document (Anon 2008b). The documents were developed in consultation with various stakeholders, after many public meetings.

During these meetings, the apparent conflict in opinion between wildlife conservation officials and wildlife rehabilitators encouraged the inauguration of the first assessment of rehabilitation centres in South Africa, to determine the degree of dichotomy between wildlife rehabilitation and conservation efforts. Following this, I wanted to determine the need for wildlife rehabilitation in a community in South Africa, since most of the published inventories of intake trends, across species and time, have been in rehabilitation centres in the developed countries of temperate zones (England: Molony et al 2007; U.S.A: Hartup 1996, Harden et al 2006, Neese et al 2008; Canada: Dubois 2003), and no comprehensive studies have been conducted in the developed African urban context. I, therefore, set out to investigate animal intake trends over four years at one of the largest urban wildlife rehabilitation centres in South Africa. These two studies provided the context in which to explore the most important determinant of wildlife rehabilitation success, namely post-release success.

There is a general lack of post-release monitoring of rehabilitated animals, as mentioned earlier. In South Africa there are few known cases, although rehabilitation centres release animals on an almost daily basis. There is thus an urgent need for scientific studies that document the fate of these animals once released, to prevent euthanasia and captivity being the only options available for rehabilitated animals, as advised for confiscated (IUCN 2000) and orphaned (Soorae 2005) animals, and currently explored as placement options by the South African government conservation agencies. I, therefore, documented the post-release success of rehabilitated vervet monkeys (*Cercopithecus aethiops pygerythrus*) and Babcock's leopard tortoises (*Stigmochelys pardalis babcocki*). The post-release monitoring of a third species, rock hyrax (*Procavia capensis*), was presented as a further case study, even though individuals were not from a rehabilitation centre. Vervet monkeys and Babcock's leopard tortoises were chosen based on them being the most frequently admitted species of Primates and Chelonia to rehabilitation centres in KZN. Previous releases were poorly monitored, but poor survival has been generally supposed (A. Armstrong EKZNW pers. comm.; J. Harris EKZNW pers. comm.). Only one scientific study has determined the post-release success of two troops of vervet monkeys from a rehabilitation centre. Monitoring of troops was limited, and success was only determined after one week post-release for one troop, and one month for the other (Rhind & Lawes 1998). The two studies on vervet monkeys and Babcock's leopard tortoises were thus conducted to assist EKZNW in investigating methods of release in an effort to improve post-release success, while minimising risks to biodiversity. The study on rock hyrax was investigated as a result of them being re-introduced into areas in KZN since 2004, due to localised extinctions, but no documented post-release monitoring has been done to assess their success. There have only been three published accounts of rock hyrax translocations (Crawford & Fairall 1984; Hoeck 1982, 1989), but post-release monitoring was limited and few details were provided.

OBJECTIVES AND FORMAT OF THE THESIS

The thesis is arranged as chapters prepared for publication in peer-reviewed journals, and thus any repetition in the chapters (e.g. introduction) was unavoidable.

Chapter 2 is titled: "A survey of wildlife rehabilitation in South Africa: is there a need for improved management?" My objectives were to determine the degree of dichotomy between wildlife rehabilitation and conservation efforts, by providing the first assessment of rehabilitation centres in South Africa, in terms of numbers of centres and animals, the species rehabilitated, pre- and post-release protocols, and economics. Included in this objective, I set out to determine the necessity of adoption of primate (and possibly others) rehabilitation norms and standards, and their likely enforcement. I predicted that there would be a need for improved management of South African wildlife rehabilitation centres, and that the dichotomy observed between rehabilitation and conservation in South Africa would be similar to that reported internationally.

Chapter 3 is titled: “Annual intake trends of a large urban animal rehabilitation centre in South Africa: a case study.” My objective was to gain further insight into the need for wildlife rehabilitation in a community in South Africa, by providing the first comprehensive investigation of animal intake trends of an urban wildlife rehabilitation centre in South Africa. I predicted that there would be no difference in the general trends of intake rates, and causes for intake, for international centres within suburban and urban environments. However, I predicted a greater species diversity in South Africa, than those reported in the northern hemisphere, as a result of being in a different biogeographical realm, with relatively high biodiversity.

Chapter 4 is the first out of three case studies on post-release monitoring, and is titled: “Post-release success of two rehabilitated vervet monkey (*Cercopithecus aethiops pygerythrus*) troops in KwaZulu-Natal, South Africa.” My objectives were to test the efficacy of the release protocol developed by EKZNW (in conjunction with the rehabilitation centre), and to provide the first long-term documented post-release monitoring of rehabilitated South African primates. Therefore, I set out to determine whether the two troops would successfully adapt to being released into the wild, where success was assessed in terms of a rescue/welfare release (Baker 2002), namely similarities in survival, reproductive success and home range establishment to wild troops (Farmer et al. 2006; Cheyne et al. 2008), during one year post-release. I assumed that individuals in both troops had been rehabilitated successfully, and that the release site was suitable based on the rehabilitation centre feedback and on the EKZNW permit for permission to release. I thus predicted that both troops would remain cohesive outside the captive environment and have similar survival, reproductive success and home range establishment to that observed in wild troops. I also predicted that the larger rehabilitated vervet monkey troop would be more successful (e.g. higher survival) than the smaller troop, due to the larger group size offering protection from predators and greater advantage over foraging resources (Isbell et al. 1990). I could not predict whether individuals with experience in the wild would be more successful than those who had been hand-raised, because individual histories were unknown.

Chapter 5, the second case study, is titled: “Can rehabilitated leopard tortoises, *Stigmochelys pardalis*, be successfully released into the wild?” My objectives were to test the efficacy of the release protocol developed by EKZNW, and to provide the first documented post-release monitoring of rehabilitated South African tortoises. Therefore, I wanted to determine whether rehabilitated *S. p. babcocki* could be successfully released into the wild. Whether the release was successful or not was assessed in terms of the aims of a rehabilitation (and not a translocation e.g. reintroduction) release, namely survival (Waples and Stagoll 1997), site fidelity (which is linked to survival; Burke 1989) and causes of death, whether natural or as a result of other factors (e.g. not adjusting to release). I assumed that the leopard tortoises had been rehabilitated successfully, and were released into suitable habitat based on the rehabilitation centre feedback and on the EKZNW permit for permission to release. I thus predicted that survival would be similar to that observed in wild leopard tortoises, and the cause of any deaths would be natural. I also predicted that the released tortoises would show site fidelity, because of the suitability of the release site.

Chapter 6, the third case study, is titled: "Two unsuccessful re-introduction attempts of rock hyrax (*Procavia capensis*) into a reserve in the KwaZulu-Natal Province, South Africa." My objective was to provide further insight into the fate of translocated/re-introduced rock hyrax. Success of release was assessed in terms of a reintroduction, such that the objective was to have a self-sustaining population of released animals (IUCN 1998). For the first release, I assumed that the rock hyrax would remain cohesive once they were released into the wild, because they had been together in captivity for over a year. I also assumed that they would remain near the point of release because of the suitability of the release site, and because the release was done according to current translocation practices in the province (i.e. hard release). For these reasons I predicted that this group of rock hyrax would be successfully released into the wild. For the second release, I assumed that the rock hyrax would remain cohesive once they were released into the wild, because they had been caught from the same site (and likely know each other) and they were kept in a holding cage at the release site (soft release protocol). I also assumed they would stay near the release site, because the release site was suitable and because they had been soft released. As a result of these assumptions, I predicted that this group of rock hyrax would be successfully translocated.

Chapters 4 – 6 are presented as case studies, because of the small sample sizes and lack of experimental replication. Even though attempts were made to increase sample size and control variables, it was mostly out of my control, as I wanted to test established protocols to determine whether they would result in post-release success of the animals released. I thus had no control over the rehabilitation or release protocol in Chapters 4 and

5. In Chapter 6, for the first release of captive rock hyrax, I followed the common practices employed by EKZNW.

Chapter 7 is the concluding chapter, titled: “Wildlife rehabilitation in South Africa”. My objective with this chapter was to summarise the various components of the thesis and propose management and research recommendations.

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Table 1: Literature review of studies that have monitored the post-release success of rehabilitated wild animals. Studies were not included if the individuals were captive bred (e.g. mandrills, *Mandrillus sphinx*: Peignot et al. 2008) or if wild individuals were translocated from one site to another (e.g. howler monkeys, *Alouatta pigra*: Ostro et al. 1999; gopher tortoise, *Gopherus polyphemus*: Ashton & Burke 2007).

Class	Order	Common name	Scientific name	Reason for rehabilitation	Country	Monitoring method	Survival (number survived, time post-release)	Refs
Bird	Anseriformes	Mute swan	*Cygnus olor*	Oiled	Ireland	Ring recoveries, and re-sightings	After 4 months, 79% of oiled & rehabbed (n=42) alive vs. 92% of non-oiled & non-rehabbed (n=122). At end of 4 years, known survival for rehabbed was 24% (13 known deaths) vs. 39% for wild. Only one rehabbed individual bred in first year, but breeding success increased in subsequent years	Collins et al. 1994
	Charadriiformes	Western gull	*Larus occidentalis*	Oiled	USA	Radio-telemetry	Oiled & rehabbed (n=7) vs. no oil & rehabbed (n=10) vs. no oil & no rehab ("wild") (n=10): 100% survival for 127 days (except 1 wild), then lost radio-contact	Golightly et al. 2002
	Charadriiformes	Hooded plover	*Thinornis rubricollis*	Oiled	Australia	Visual	Two of two survived at least 2 years	Weston et al. 2008
	Charadriiformes	Various, but mainly Common Guillemot, Velvet Scoter, Western Grebe	*Uria aalge, Melanitta fusca, Aechmophorus occidentali, A.clarkii*	Oiled	USA	Ring recoveries (n=127, t=35 yrs)	Most (94%) of recoveries for guillemot (n=78) was within 60 days of release, expected life expectancy was 9.6 days. Average survival for other seabirds was 4-11 days	Sharp 1996
	Ciconiiformes	Cape Gannet	*Morus capensis*	Oiled	South Africa	Ring recoveries (n=16)	Estimated annual survival rate was 0.84-0.88 for 932 individuals	Altwegg et al. 2008
	Ciconiiformes	California brown pelican	*Pelecanus occidentalis califormicus*	Oiled	USA	All ringed, some had radio-telemetry (n=42)	Only 9% of oiled & rehabbed (n=112) alive after 2 years versus non-oiled & non-rehabbed (53% of 19). Also no breeding by rehabbed.	Anderson et al. 1996
	Ciconiiformes	Little Penguin	*Eudypula minor*	Oiled	Australia	Ringing and trapping	Estimated survival of 53% of 1788 after 20 months	Goldsworthy et al. 2000
	Ciconiiformes	African Penguin	*Speniscus demersus*	Oiled	South Africa	Ringing and re-sighting	60% rehabilitated penguins breeding 6 years later	Wolfaardt & Nel 2003
	Ciconiiformes	African Penguin	*Speniscus demersus*	Oiled	South Africa	Ringing and re-sighting	2006: survival estimated at 70% of 9707 (oiled & rehabbed) vs. 40% of 2028 (not oiled & relocated) vs. 34% of 1055 (hand-reared orphaned chicks) after 4 years 2008: Survival to breeding and breeding success of hand-rearing orphaned chicks similar to chicks raised by wild parents, as analysed 1-6 years after oil spill	Barham et al. 2006; Barham et al. 2008

Table 1. cont: Literature review of studies that have monitored the post-release success of rehabilitated wild animals.

Class	Order	Common name	Scientific name	Reason for rehabilitation	Country	Monitoring method	Survival (number survived, time post-release)	Refs
Bird	Gruiformes	American coot	*Fulica americana*	Oiled	USA	Visual and radio-telemetry	*Note that oiled & rehabbed and non-oiled & non-rehabbed groups ("wild") released only into enclosures at university, not into wild Anderson: survival of oiled & rehabbed (n=37) lower (49%) versus wild (76% of n=38) after 4 months. Newman: rehabbed & oiled (n=47) showed inflammatory response in blood results, which was not shown by wild (n=?), but after 3.5 months blood results were similar.	Anderson et al. 2000; Newman et al. 2000
	Falconiformes	Common buzzard	*Buteo buteo*	Injured, illness	Italy	Radio-telemetry	From 16 released, 6 dead within 103 days, mostly electrocuted, but also gunshot & starvation. Half dispersed from release site within 3 days, but last one left at 103 days. Some attacked by wild conspecifics	Csermely & Corona 1994
	Falconiformes	Peregrine falcon	*Falco peregrinus*	Injured	USA	Ringing, re-sighting, band returns	Estimated minimum first year survival of 66 released was 14% (n=9). One known to be alive after 5 years. Only 10% formed territories, while 6% nested.	Sweeny et al. 1997
	Falconiformes	Red-tailed hawk, Red-shouldered hawk	*Buteo jamaicensis, B. lineatus*	Injured, confiscated, fallen from nest	USA	Radio-telemetry	Red-tailed: 4 of 8 survived >2 weeks (1 known death-unknown cause). Status of rest unknown due to signal loss. Red-shouldered (n=1) tracked for longest (59 days), but then killed (shot). Most remained near release site for few days.	Hamilton et al. 1988
	Falconiformes	Bald eagle	*Haliaeetus leucocephalus*	Injured	USA	Leg band, radio-telemetry	Most (68% of 19) survived 6 weeks, 3 known deaths (leg-hold trap, poisoning, unknown). Fate of others unknown due to signal loss. One survived 835 days and successful nested. Most remained near release site for few days.	Martell et al. 1991
	Falconiformes	Bald eagle	*Haliaeetus leucocephalus*	Injured, starvation	USA	Re-sightings of patagial tags	Nine of 11 remained in area where released, up to 45 days. Seemed to learn best feeding and perching sites from wild eagles in area. One seen at least 1 year after release	Servheen & English 1979
	Psittaciformes	Yellow-shouldered Amazon (parrot)	*Amazonia barbadensis*	Orphaned, confiscated	Venezuela	Radio-telemetry (n=4)	Most (83% of n=12) survived 1 year. One survived at least 3 years and successfully reproduced. All (except 2, who disappeared) joined wild groups.	Sanz & Grajal 1998
	Strigiformes	Long-eared owl, tawny owl	*Asio otus, Strix aluco*	Orphaned	Italy	Radio-telemetry	Long-eared (n=8): dispersed from release site within 2-11 days, 4 deaths within 1 week (mostly starvation). Tawny (n=8): 1 dead from predation within 3 days, left release site within 7-79 days.	Csermely 2000
	Strigiformes	Tawny owl	*Strix aluco*	Orphaned	UK	Radio-telemetry (n=16) & leg-band recoveries (n=112, t=10 yrs)	Radio-tracking: 2 lost tags, 3 dead (starvation & predation) and 13 alive within 84 days 67% of 18 survived 6 weeks, 39% more than 1 year, deaths due to emaciation, predation, traffic collisions	Leighton et al. 2008

Table 1. cont: Literature review of studies that have monitored the post-release success of rehabilitated wild animals.

Class	Order	Common name	Scientific name	Reason for rehabilitation	Country	Monitoring method	Survival (number survived, time post-release)	Refs
Bird	Strigiformes	Barn owl	*Tyto alba*	Captive bred and injured	Spain	Analysed intake records (n=41)	Survival estimated at 78 days versus wild at 365 days. Deaths mostly due to vehicle impact and starvation (mostly within 4 weeks).	Fajardo et al. 2000
	Strigiformes	Barn owl	*Tyto alba*	Orphaned/ abandoned, possible ex-pet	USA	Visual, jesses	Out of 10 young placed with wild broods, all except 2 fledged. One of those who fledged was seen nesting successfully a year later. A tame 1-year old female escaped from captivity and found alive and breeding a year later	Marti &Wagner 1980
	Strigiformes	Eagle owl	*Bubo bubo*	Unknown	Spain	Only some radio-telemetry (n=9)	After 101 days, 19 of 64 dead	Zuberogoitia et al. 2003 (abstract only-document in Spanish)
	Strigiformes and Falconiformes	Various, but species recovered are: Greater Horned owl, Barred owl, Screech owl; Red-tailed hawk, Rough-legged hawk, Broad-winged hawk, Bald eagle, Golden eagle	*Bubo virginianus, Strix varia, Otus asio; Bueto jamaicensis, B.lagopus, B.platypterus, Haliaeetus leucocephalus, Aquila chrysaetos*	Injured, nestlings	USA	Ringing (all), radio-telemetry (n=4, Bald eagles only)	Total of 648 raptors released over 6 years. Strigiformes: 14 (8%) recovered (between 14-1110 days after release): 8 found dead, 3 emaciated, 1 caught in mammal trap, 1 stuck in warehouse, 1 caught by hand but released. Only 21% recovered within 6 weeks. Falconiformes: 11 (2%) recovered (between 7-255 days after release): 7 dead, 2 emaciated, 1 weak-recaptured and released, alive but injured. Over half (54%) recovered within 6 weeks. A bald eagles sighted up to 2 years after release, also reproductive success	Duke et al. 1981
	Various (Ciconiiformes, Anseriformes (n=2), Falconiformes (n=3), Charadriiformes (n=2), Strigiformes (n=3))	Gannet, Mute Swan, Mallard, Sparrowhawk, Buzzard, Kestrel, Herring gull, Guillemot, Barn owl, Little owl, Tawny owl	*Morus bassanus, Cygnus olor, Anas platyrhnchos, Accipiter nisus, Buteo buteo, Falco tinnunculus, Larus argentatus, Uria aalge, Tyto alba, Athene noctua, Strix aluco*	Ill, injured, oiled	UK	Ring recoveries	Rehabbed birds had significantly shorter survival than wild birds monitored. Most rehabbed birds died within 1 year post-release	Clark et al. 2004

Table 1. cont: Literature review of studies that have monitored the post-release success of rehabilitated wild animals.

Class	Order	Common name	Scientific name	Reason for rehabilitation	Country	Monitoring method	Survival (number survived, time post-release)	Refs
Mammal	Artiodactyla	Roe deer	*Capreolus capreolus*	Orphaned	Italy	Radio-telemetry	Two of two survived minimum 1 year	Pandini & Cesaris 1997
	Artiodactyla	White-tailed deer	*Odocoileus virginianus*	Orphaned	USA	Radio-telemetry	Out of 42 released, 52% died within 30 days, mainly by canid, while those that survived stayed around humans. Deaths due to being unfamiliar with new surroundings and lack of predator avoidance	Beringer et al. 2004
	Carnivora	Coastal river otters	*Lontra canadensis*	Oiled (fed oil on purpose)	USA	Radio-telemetry	Experimental group: control (n=5), low dose (n=5) and high (n=5) dose of oil, vs. wild (n=55). Post-release survival 6-442 days (experimental) vs. 42-924 days (wild). Wild: 13% dead, 27% missing (survival rate 76%) within 442 days vs. experimental: 67% dead, 20% missing (survival rate 17%) Experimental individuals died due to starvation, predation, accidents, while wild died from starvation, natural causes and injury. Time in captivity may decrease survival.	Ben-David et al. 2002
	Carnivora	Southern sea otters	*Enhydra lutris nereis*	Stranded	USA	Radio-telemetry	Survival of pups reared with surrogate mother (n=7) had higher survival (71%) vs. those reared without (n=26) surrogate mother (31%), and similar to survival of wild individuals (75%, n=12). They had learnt skills to forage properly	Nicholson et al. 2007
	Carnivora	Giant otters	*Pteronura brasiliensis*	Orphaned	Guyana	Visual	At least 15 of 18 survived 4 years post-release	McTurk & Spelman 2005
	Carnivora	Red fox	*Vulpes vulpes*	Orphaned (n=18) and captive-bred (n=8)	UK	Radio-telemetry	Two groups: with (n=9) and without (n=26) site acclimatisation. Both groups showed erratic (and long-distance) dispersal from release site for 1-5 weeks, but it was delayed for those with acclimatisation. Those without acclimatisation settled after an average of 17 days. Within 3 weeks, only 9 known to be alive, with 12 known dead. Minimum survival of 2 foxes is 6 months. Mortality due to vehicle impact. Tameness apparent in some released animals.	Robertson & Harris 1995
	Carnivora	American black bear	*Ursus americanus*	Orphaned	USA	Visual	Survival differed with rehab method (9-79%). Low survival is when cubs killed by intended foster mothers. Human-imprinted cubs a problem	Alt & Beecham 1984
	Carnivora	American black bear	*Ursus americanus*	Orphaned	USA	Radio-telemetry	After 122 days, 7 of 11 alive, but by 9 months only 2 known to be alive. Unknown fate due to dropped collars.	Clark et al. 2002
	Carnivora	Stone martens	*Martes foina*	Orphaned (n=4) & relocated (n=1)	Belgium	Radio-telemetry	Relocated individual died within 7 days, but all 4 survived at least 130 days, but then 1 known death (collar strangulation), lost signal for 2 and so only 1 alive at 217 days. Three remained near release site for 1 month.	Herr et al. 2008
	Carnivora	Wolf	*Canis lupus*	Injured	USA	Visual	One of one survived minimum 4.5 years	Thiel 2000

Table 1. cont: Literature review of studies that have monitored the post-release success of rehabilitated wild animals.

Class	Order	Common name	Scientific name	Reason for rehabilitation	Country	Monitoring method	Survival (number survived, time post-release)	Refs
Mammal	Cetacea	Common dolphin, Harbor porpoise	*Delphinus delphinus, Phocoena phocoena*	Stranded	USA	Radio-telemetry	Dolphins (n=2) tracked for 3-31 days, then lost signal, while 1 porpoise survived at least 5 months	Zagzebski et al. 2006
	Cetacea	Harbor porpoise	*Phocena phocoena*	Stranded	USA	Radio-telemetry	One individual survived 50 days, then signal lost	Westgate et al. 1998
	Cetacea	Risso's dolphin	*Grampus griseus*	Stranded	USA	Radio-telemetry	One individual survived 23 days, then signal lost	Wells et al. 2009
	Cetacea	California gray whale	*Eschrichtius robustus*	Calf (probably stranded)	USA	Radio-telemetry	One of one tracked for 3 days, then telemeter came off.	Stewart et al. 2001
	Cetacea	Longfinned pilot whale	*Globicephala melas*	Stranded	USA	Radio-telemetry (n=1)	Only individual with radio-telemetry (out of 3 released) seen after release, up to 94 days. It was seen at 20 days with wild group.	Mate et al. 2005
	Cetacea	Longfinned pilot whale	*Globicephala melas*	Stranded	USA	Radio-telemetry	Two individuals survived at least 4 months. They seemed to stay together	Nawojchik et al. 2003
	Chiroptera	Pipistrelle bats	*Pipistrellus sp*	Abandoned	UK	Radio-telemetry	First releases: all 7 of 7 taken back or died within 3 days, but second release (with longer pre-release training in big flight aviary): 5 of 5 survived minimum 2 weeks.	Kelly et al. 2008
	Chiroptera	Grey-headed flying foxes	*Pteropus poliocephalus*	Orphans	Australia	Radio-telemetry	3 releases (n=28, 48, 31) over 3 years. The release that was 1 month earlier and with shorter supplementary feeding resulted in success, with 100% integration with wild colony within 20 days	Augee & Ford 1999
	Diprotodontia	Koala	*Phascolarctos cinereus*	Burnt in fire	Australia	Radio-telemetry	No difference in annual survival for rehabbed (58% of n=16) vs. wild (67% of n=23). 9 rehabbed and 9 wild died, mainly due to predation by dogs. After 3 years, 5 rehabbed and 8 wild still alive.	Lunney et al. 2004
	Diprotodontia	Ringtail possums	*Pseudocheirus peregrinus*	Orphaned and relocated adults	Australia	Radio-telemetry	No difference in survival between hand-reared (n=92) and relocated (n=21), but these two groups had lower survival (101 d) than wild (182 d for n=40), especially within first 100 weeks. However, none known to be alive 4 years later, with 118 (of 153) mostly killed by predators (most by foxes and cats), but some died in bushfires, and from vehicle impact.	Augee et al. 1996
	Insectivora	European Hedgehogs	*Erinaceus europaeus*	Injured/ late born juveniles	UK	Radio-telemetry	1993: 3 of 7 alive after 6 weeks. Deaths due to illness, vehicle collision, and drowning. They dispersal from release site; 1994: 7 of 12 alive after 5 weeks. Deaths due to predator and vehicle collision; 1997: 10 of 13 alive after 6 weeks.	Morris 1997; Morris et al. 1993; Morris & Warwick 1994

Table 1. cont: Literature review of studies that have monitored the post-release success of rehabilitated wild animals.

Class	Order	Common name	Scientific name	Reason for rehabilitation	Country	Monitoring method	Survival (number survived, time post-release)	Refs
Mammal	Insectivora	European Hedgehogs	*Erinaceus europaeus*	Injured/ late born juveniles	UK	Radio-telemetry	After 15 weeks, 3 of 12 alive, with 7 known deaths due to illness, vehicle collision, drowning, and predation. Less dispersal if released in urban vs. rural area. Tameness may make them susceptible to predation.	Reeve 1998
	Insectivora	European Hedgehog	*Erinaceus europaeus*	Injured/ late born juveniles	UK	Radio-telemetry	After 8 weeks, 73% survived from 20.	Molony et al. 2006
	Primates	Müllers Bornean gibbon	*Hylobates muelleri*	Ex-pets, orphans	Malaysia	Visual	Over 11 years, 87 released, but fewer than 10 known to be alive at end of 11 years. They were generally not ready for release (too young)	Bennett 1992
	Primates	Agile gibbon	*Hylobates agilis*	Ex-pets	Indonesia	Visual	2004: Out of two released, 1 brought back to captivity (attacked by wild conspecific), other 1 survived minimum 2 yrs and found wild male mate 2005:100% of 4 survive 2 years 2008: 100% of 2 survive 8 months	Cheyne & Brulé 2004; Cheyne 2005; Cheyne et al. 2008
	Primates	White-handed/ Lar gibbon	*Hylobates lar*	Ex-pets	Thailand	Visual	About 5 years later 10 of 16 alive. Two known to have died, 4 had to be re-captured. Successful reproduction. Had up to 10 years pre-release training.	Shanee & Shanee 2007
	Primates	Common chimpanzee	*Pan troglodytes*	Ex-zoo animals, orphans	Tanzania	Visual	Only 2 of 17 known to be alive 10 years later. Some were reported to have attacked people. But successful reproduction.	Borner 1985
	Primates	Common chimpanzee	*Pan troglodytes*	Ex-pets, laboratory, zoo animals	Liberia	Visual, some radio-telemetry	22 released onto island; intense post-release support e.g. providing food, humans walking with them. But some immediately fled from release site, others suffered from illness, some returned to captivity because of not adapting to release and 1 killed by conspecifics. As a result of dry season, wild individuals could come onto their island, so all returned to laboratory.	Hannah 1986 (in Hannah & McGrew 1991)
	Primates	Common chimpanzee	*Pan troglodytes*	Ex-zoo animals, orphans	Republic of Congo	Radio-telemetry (n=34/37)	Over 5 years: 37 released (with up to 11 yrs pre-release conditioning on island). After 8 years: 62% known survival, with 14% confirmed deaths (drowning, killed by conspecifics). Some fled immediately after release. Very aggressive encounters with wild males resulted in intense veterinary intervention. Successful reproduction.	Goossens et al. 2005; (earlier studies: Tutin et al. 2001; Farmer & Jamart 2002; Farmer et al. 2006)
	Primates	Golden lion tamarin	*Leontopithecus rosalia*	Mostly captive bred, some ex-pets	Brazil	Dye, radio-telemetry	After 7 years, 33 of 91 alive and successful reproduction. Deaths due to theft by humans, predation, disease, exposure, and mainly starvation (they had difficulty in finding food and in locomotion)	Beck et al. 1991 (Kleiman et al. 1986)

Table 1. cont: Literature review of studies that have monitored the post-release success of rehabilitated wild animals.

Class	Order	Common name	Scientific name	Reason for rehabilitation	Country	Monitoring method	Survival (number survived, time post-release)	Refs
Mammal	Primates	Lowland gorilla	*Gorilla gorilla*	Orphans, ex-pets, few ex-situ captive-born	Gabon	Visual	Long soft-release (average 15 months) of two troops (n=13 each): they are supplementary fed and staff takes them for walks in forest, and in enclosure at night. 85% survival 3 years post-release, 2 confirmed deaths (drowning, disease) and 1 birth. Two troops are stable.	Pearson et al. 2007
	Primates	Bornean orangutan	*Pongo pygmaeus*	Probable ex-pets	Indonesia	Visual	Over 2 years: 27 released. 12 yrs later: 11 alive, 2 deaths, 3 relocated (attacked humans) and rest disappeared. Some have wounds from wild conspecifics or predators. Successful births-but high infant mortality. Some still dependent on supplementary food and interact with humans.	Yeager 1997
	Primates	Guianon/ Margarita Island Brown capuchin	*Cebus apella*	Ex-pets	Columbia	Dye	Out of 8, 5 known to have survived 6.5 months and remained in the group. Important for groups to be cohesive and have lengthy pre-release training (5 months).	Suarez et al. 2001
	Pinnipedia	Grey seal	*Halichoerus grypus*	Stranded pups	France	Re-sighting of tags, some had radio-telemetry (n=4).	Overall, 48% of those released (n=92) re-sighted after release, 21% found dead. Mortality rate estimated at 20-43%. Some re-sighted up to 5 years post-release	Vincent et al. 2002
	Pinnipedia	Harbour seal	*Phoca vitulina richardsi*	Stranded pups	USA	Radio-telemetry	Estimated survival after 5 months similar for rehabbed (n=29) vs. wild (n=24) (survival= 0.271 vs. 0.517 respectively). Only known deaths: 1 wild pup (emaciation) and 1 rehabbed pup brought back (diseased)	Lander et al. 2002
	Pinnipedia	Steller sea lion	*Eumetopias jubatus*	Stranded pups	USA	Radio-telemetry	All 3 survived minimum of 1 month, then lost signal. 1 known to be alive after 4 months.	Lander & Gulland 2003
	Sirenia	West Indian manatee	*Trichechus manatus*	Stranded orphans	Brazil	Radio-telemetry	One of one survived at least 9 years. Successful reproduction.	Lima et al. 2005
	Sirenia	West Indian manatee	*Trichechus manatus*	Stranded orphans	Puerto Rico	Radio-telemetry	One of one survived 4 years, but continued to supplementary feed. Doesn't seem to be able to find the right or enough food	Mignucci-Giannoni 1998

Table 1. cont: Literature review of studies that have monitored the post-release success of rehabilitated wild animals.

Class	Order	Common name	Scientific name	Reason for rehabilitation	Country	Monitoring method	Survival (number survived, time post-release)	Refs
Reptile	Chelonia	Eastern box turtle	*Terrapene c. carolina*	Ex-pets, rehabbed injured, lost habitat	USA	Radio-telemetry	Over 5 years, 6 of 33 died (due to nutrient depletion, predation). Most dispersal widely from release site, but were brought back. Without supplementary food, deaths would have been higher	Belzer 1999
	Chelonia	Eastern box turtle	*Terrapene c. carolina*	Relocated from development sites and ex-pets	USA	Radio-telemetry	In first 2 years, 64% of 53 annual survival, and 84% annual survival over next 3 years. Death due to dispersal from site and pneumonia.	Cook 2004
	Chelonia	Eastern box turtle	*Terrapene c. carolina*	Ex-pets, rehabbed injured and displaced	USA	Radio-telemetry on some (n=4)	Out of 46 released, 8 died (field-mower, vehicle-induced), 9 known to have survived 1 year. Rehabbed individuals travelled greater distances than wild residents (n=18).	Lee 2004
	Chelonia	Gopher tortoise	*Gopherus polyphemus*	Probable ex-pets, and relocated	USA	Visual	Different release methods, no duration given. Less successful (1/19 successful) if not penned and in areas with other tortoises vs. penned and no tortoises (17/21 successful). Success if new burrows were found in release site	Lohoefener & Lohmeier 1986
	Chelonia	Various freshwater turtles (painted, snapping, red-eared slider, red-bellied)	*Chrysemys picta, Cheludra serpentina, Trachemys scripta, Pseudemys rubriventris*	Oiled	USA	Radio-telemetry	Three groups had similar mortality rates within 6 months, with 25% for oiled & rehabbed (n=16), 22% for possible oiled & no rehab (n=18) and 31% for not oiled & not rehabbed (n=32). Many transmitters lost, but also probable predation. Home ranges similar between groups	Saba & Spotila 2003

CHAPTER 2

A survey of wildlife rehabilitation in South Africa: is there a need for improved management?

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Abstract

The focus of wildlife rehabilitation is the survival of the individual animal, often leading to rehabilitators being in conflict with government wildlife officials, who regulate the wildlife rehabilitation industry and whose focus is on the security of entire wildlife communities. In South Africa, wildlife rehabilitation has been the focus of recent attention to the general public, government and academics, mostly due to the development and adoption of norms and standards for the management of primates. Our study was initiated to provide the first survey of rehabilitation centres in South Africa. Questionnaires were returned by 65% known rehabilitation centres from all nine provinces in South Africa. Several thousand injured, diseased and orphaned animals pass through these centres each year, clearly showing the need for rehabilitation centres in South Africa. However, due to a lack of scientific research on the efficacy of rehabilitation methods for care and release, and minimal post-release monitoring, the authors found that work experience and subjective intuition drove most rehabilitation practices. Additionally, because personnel from most centres cites lack of finance as a main impediment to the goal of rehabilitation, the result of rehabilitation may include negative impacts on individual animal welfare and

survival, as well as on conservation efforts for wildlife communities. Similar issues have been documented in other parts of the world. In the authors' opinion, wildlife rehabilitation needs to be centralised to the national or provincial government. Furthermore, it is suggested that guidelines of minimum standards should be developed in consultation with experienced rehabilitators, veterinarians and conservation scientists; to be enforced by trained and dedicated wildlife conservation officials.

Keywords: animal welfare, conservation, government, minimum standards, South Africa, wildlife rehabilitation

Introduction

Wildlife rehabilitation is defined as the treatment of injured, ill and orphaned wild animals, under temporary care, with the goal of releasing them back into their natural habitat (Trendler 1995a; Anon 2008a). It is often seen as playing a vital role in conservation and increasing the public awareness of animal welfare issues (as reviewed by Kirkwood 1992; Trendler 1995a; Aitken 2004). Others, however, believe wildlife rehabilitation can have negative impacts on conservation. For example, it could divert money away from habitat protection (as reviewed by Kirkwood 1992) and when rehabilitated animals are released, it could place wild populations at risk (eg disease and genetic pollution) (as reviewed by IUCN 2000, Measures 2004 and Soorae 2005). Therefore, there is a dichotomy in opinion, whereby rehabilitators focus on the individual animal and government wildlife officials focus on the security of entire wildlife communities (Dubois 2003; Aitken 2004).

Differences in perceptions between government wildlife officials, who issue and enforce permits, and rehabilitators, were examined in Canada to determine whether this would prevent effective communication and co-operation between these groups (Dubois & Fraser 2003a). Both saw the main goals of rehabilitation as caring for injured and orphaned wildlife until release, or if necessary, euthanasia, as well as educating the public to prevent these problems in the future (Dubois & Fraser 2003a). However, officials did not acknowledge additional contributions mentioned by rehabilitators, such as contributing to wildlife conservation and research (Dubois & Fraser 2003a). Both groups stated that the main impediments to rehabilitation was a lack of funding, while only rehabilitators mentioned the lack of support and acknowledgement by government as an additional impediment (Dubois & Fraser 2003a). Contrasting views were also apparent in the role played by enforcement in rehabilitation, where rehabilitators believed that issuing and control of permits was not strict enough, while wildlife officials thought that there was enough enforcement, but agreed that some permit applications were approved without inspection, and officials were generally not qualified to assess quality of care at centres (Dubois & Fraser 2003b).

Jointly, the International Wildlife Rehabilitation Council (IWRC) and National Wildlife Rehabilitators Association (NWRA) in the United States of America (USA) created minimum standards for wildlife rehabilitation in an attempt to increase the post-release success of rehabilitated animals by providing standards and guidelines for their care, and preparation for their release (Miller 2000). Guidelines for all aspects of the rehabilitation process are emphasised, starting from admission of the animal (eg intake records), health checks, disease control, housing requirements and decisions around release (Miller 2000). This document has been adopted by some states in the

USA as permitting guidelines (Miller 2000); and has been used by western Australia to develop its own minimum standards (Anon 2008b). However, an attempt by IWRC and NWRA to have a certification programme, where completion would mean that the person has "met minimum knowledge standards set by peers in the field" (Gurso 2006); has been opposed by some rehabilitators (Kosch-Davidson et al. 2006).

In addition to welfare implications, non-compliance with established minimum standards could potentially result in the loss of useful information. An example is the general lack of adequate record keeping by centres (eg Fajardo et al. 2000; Dubois & Fraser 2003c), which makes it hard to assess successes or failures of rehabilitation methods (Trendler 1995a; Miller 2000). Similarly, because post-release monitoring is rarely done (eg in Spain: Fajardo et al. 2000), success of a release cannot be determined (Verdoorn 1995; IUCN 2000), and the rehabilitation process modified accordingly (Clark et al. 2002; Beringer et al. 2004). Even if releases are monitored, there is disagreement as to what defines "success", whereby a release could have 90% mortality, but be deemed successful in terms of breeding and loss of dependence on humans in the surviving animals (Borner 1985). A primary factor contributing to a lack of post-release monitoring is its low funding priority (Kirkwood & Sainsbury 1996; Lloyd 1999, Dubois & Fraser 2003c). Rehabilitation centres are not supported by local government, and thus are dependent on their own money (Jacobs 1998), or money made from merchandise sales, memberships, public relations functions, charitable private donations (including bequests) (Kunz 1995) or corporate sponsorship (Reynolds 1995). Furthermore, most funding is normally spent on food for animals, housing, medication, and veterinary care (Trendler 1995b; Jacobs 1998), as well as on staff salaries (Kunz 1995).

Wildlife rehabilitation in South Africa was started by nature conservation agencies in the 1950s, but by the late 1980s rehabilitation became a low priority for conservation and it moved into the private sector (Carr 1995). A few years later the first wildlife rehabilitation conference was held, where minimum standards for care (Trendler 1995a) and release (Verdoorn 1995) were presented, as well as plans to form a "Rehabilitation Council" (Lockwood 1995, p35). This has been the only national rehabilitation conference, and to date nothing has come to fruition, until recently. The conservation authority Ezemvelo KZN Wildlife (EKZNW) has developed three documents pertaining to wildlife rehabilitation, namely Ex Situ Wild Animal Management Policy, Norms and Standards for Care and Management of Ex Situ Vervet Monkeys *Cercopithecus aethiops* in KwaZulu-Natal, and Norms and Standards for the Management of Primates in KwaZulu-Natal. The Board of EKZNW recently adopted the latter document (Anon 2008c). The documents were developed in consultation with various stakeholders, after many public meetings. Following these meetings, it became a permit requirement for those wanting to rehabilitate primates in KwaZulu-Natal to complete and pass a course on captive indigenous primate care and management.

During the above-mentioned meetings, the apparent conflict in opinion between government wildlife officials and wildlife rehabilitators encouraged the inauguration of our study. Our study aimed to provide the first assessment of rehabilitation centres in South Africa, in terms of numbers of centres and animals, the species rehabilitated, pre- and post-release protocols, and economics, to determine the necessity of adoption of primate (and possibly others) rehabilitation norms and standards, and their likely enforcement.

Materials and methods

All rehabilitation centres in South Africa are required to obtain a permit from the provincial government. Depending on the province, these need to be renewed on an annual or several years basis, and include specifications on the species that can be rehabilitated. Rehabilitation centres need to keep intake records, which are requested by some provinces to be sent to the permit officers on an annual basis. Presently, only the Northern Cape and the Western Cape provinces have any guidelines to assist decision-making surrounding permit applications and release of rehabilitated animals.

The permit officers for each of the nine provinces in South Africa were contacted in December 2006 for a list of all their registered rehabilitation centres. The founder or senior rehabilitator from each centre was contacted by telephone or email. The purpose of the survey was explained and they were then asked whether they would be willing to fill out the questionnaire. Due to logistical restrictions, personal visits were made to most of the centres based in only five of the nine provinces (Western Cape, KwaZulu-Natal, Gauteng, Mpumalanga, and Limpopo). Personal visits were made to ensure questionnaires were answered and to objectively verify their responses. Although there are other organisations that receive wild animals for rehabilitation, including animal welfare organisations (eg SPCA), zoological gardens and aquariums, these were not included in the survey because they are not strictly designated as rehabilitation centres in South African law. Wildlife sanctuaries were also excluded, because they are not permitted to release any animals.

The questionnaire (Appendix 1) was designed to probe rehabilitation in South Africa as broadly as possible, such that there were 48 questions in total. It included a cover page stating the purpose of the study, that confidentiality is guaranteed, and the main researcher's contact details. There were six sections, entitled: General, Animal Intake, Records, Housing, Release, Post-release, Finance and Concluding remarks.

Most questions were structured with answers listed as multiple choice, where one could select as many options as one wanted, and included an "other" option for the rehabilitators to add their own information if they felt the options given were not suitable. They were also encouraged to expand on their answers. These two reasons, as well as some rehabilitators not answering all the questions, resulted in sample sizes not being reflective of the number of respondents. Thus, the number of rehabilitators that responded to the question is represented as "n ", while "S" is used to signify the number of times an option was selected. Some questions and sections are not presented in this paper, and not all the answers that were given by the respondents for a question are listed. Only the most common answer for the "other" option is reported. Differences in responses were assessed using percentages.

Note that the answers given by rehabilitators when asked to list five common species coming into their centre (Table 3), were grouped according to animal class (ie bird, mammal, reptile). For each class, animals were placed into a category. Categories for mammals and reptiles were derived from orders or sub-orders, whereas birds were placed into categories used by the rehabilitators themselves. Several sources were used to identify order and family names for birds (Hockey et al 2005), mammals (Skinner & Chimimba 2005), and reptiles (Alexander & Marais 2007).

Results

Rehabilitation centres

Sixty-three registered rehabilitation centres in South Africa were contacted. Most of these centres occurred in KwaZulu-Natal province (Table 1). Over 65% (n = 41) of questionnaires were returned, with responses from all nine provinces. Most centres had been in existence for 6-15 years (Table 1) and most were based in private homes (Table 1). Four centres operated out of more than one property.

Goals, impediments, minimum standards and permits

The most common goals of wildlife rehabilitation (Table 2) were listed as releasing animals back into the wild, and caring for incapacitated wild animals. The main problem in obtaining these goals (Table 2) was listed as a lack of money.

When asked whether rehabilitation centres would benefit from guidelines for minimum standards for wildlife rehabilitation, most responded yes (83%, n = 34), mainly “to prevent ignorance causing unprofessional and inhumane rehabilitation”. However, many of these respondents also gave reasons against having guidelines. Combining these reasons with those given by respondents who repiled “no” to benefiting from guidelines (17%, n = 7) (Table 2), the main reasons were because “most people have this knowledge”, “they are doing a good job within their limitations”, and there is the “problem of who establishes the standards”.

When asked whether the issuing and enforcement of permits was “important and functioning correctly” (option A), “could be important, but not being enforced properly and permit conditions not strict enough” (option B), or “not useful and even a hindrance to doing rehabilitation” (option C), out of those who responded (n = 40) most chose option B (56%, n = 21), but emphasised that issuing and enforcement of permits “is important” and “permit conditions are strict enough.” Only a few rehabilitators responded to option A (27%, n = 11) and option C (17%, n = 8). The main reason given for choosing option B and C was that “unsuitable people have permits or are re-issued permits” (Table 2), while the reason given for option A (n =

11) was that rehabilitation “needs control or standards” (i.e. “not everyone should be rehabilitating animals”).

Animal intake

There was an estimated annual intake total of 16 289 animals and an average intake of 418 (± 134 SE p/a) animals admitted to 39 of the 41 surveyed rehabilitation centres across South Africa, with a range of 3 – 3600 animals. Taking into account these rehabilitation centres, birds were most commonly admitted, 83% (347 ± 120 p/a), followed by mammals, 12% (50 ± 15 p/a), and reptiles, 4% (18 ± 5 p/a). The mammals listed were from 8 different orders and 13 families, with mammals from the order Carnivora being the most common (33%); while birds came from 7 orders and 11 families, with raptors being the most common group (35%); and reptiles came from 3 orders and 7 families, with reptiles from the order Chelonia (30%) being the most common (Table 3). There was one centre that accepted frogs.

Only 2 out of 41 centres said that they rehabilitate all animal species, while those who did not (n = 39) stated that it was mainly because of specialising (Table 4). Most of the centres that were brought an animal species by the public that they did rehabilitate, would accept the animal and transfer it to another centre (Table 4), but often the decision would depend on the species.

Health checks

Most centres did not have a permanent veterinarian (Table 4). However, most (87%, n = 34) centres performed frequent health checks, compared with 8% (n = 3) who never did and 5% (n = 2) who sometimes did. The health checks (Table 4) were mainly for parasites (internal and external). Most centres had a quarantine policy (82%, n = 31), generally on arrival of an animal, while those that did not quarantine (18%, n = 7), generally believed they did not need to, as the individuals were housed separately anyway.

Record keeping

Most rehabilitation centres kept records (93%, n = 37), and the 3 that did not responded that "there was no need" and had "never been requested for it". Most rehabilitation centres believed that they could make improvements to their recording system or the way it processes the data from the records (73%, n = 27), mostly because "there is always room for improvement", including changes from hard copy to computerised records. Those that did not believe they needed improvement (27%, n = 10) mostly stated that their methods were "good enough", but some stated that they "saw no reason to do so because no one would use it".

Pre-release

Most rehabilitation centres individually marked the animals in some way to identify them while at the centre and/or post-release (60%, n = 24), compared with 40% who did not mark (n = 16). The most common method of marking was using leg bands on birds. Other methods included ear tags on mammals, radio-collars, microchips, shaving sections of fur, markings on wings (tags or windows cut into primaries), using dye, and cable ties. Those that did not mark all animals, mostly stated that it was not needed (eg data not used), while others stated it was not practically possible, the current methods were not suitable and they "never thought about it". Two respondents reported that they had received birds that were injured due to ill-fitting bird bands.

To the question “when would you not release an animal into the wild” (Table 5) most responses were “if it is an exotic species”. If the animals could not be released into the wild (Table 5), most would transfer it to a sanctuary or zoo. Several respondents made it clear that they would only send it to a sanctuary and not to a zoo as stated in the original option. Most centres euthanased animals (Table 5) when the animal had non-repairable injuries. Most additional answers to this question included that euthanasia was only performed “if no other choice”, when the animal has “absolutely no chance at having a pain free existence” or “no chance at a good quality life in captivity” (Table 5). One rehabilitator never had to have an animal euthanased, as the individual “either survives and thrives or dies”. Other centres stated that they generally did not euthanase animals because it was the centre’s policy (Table 5)

Release

Rehabilitators from the centres listed several methods for how they prepared an animal for release (Table 6), but it mainly involved placing it in a different pen, which was more natural and bigger than the other enclosures, and getting them fit (increasing muscle mass) by forced exercise. Characteristics used to judge whether an animal was fit for release (Table 6) were mainly that the individual was able to fend for itself in wild, and was healthy, but also included whether it was flying and/or walking properly and whether it was not human-imprinted.

Post-release

Most rehabilitation centres, 68% (n = 26), had monitored some of their rehabilitated animals after they had been released into the wild, mainly to determine whether the rehabilitation technique was successful (Table 7), compared with 32% (n = 12) who had never monitored. Those that had not monitored generally said that they would start monitoring (Table 7) if they had more money for monitoring. Duration of monitoring was largely dependent on the species or individual, compared with other factors, such as how practical it is to monitor (eg declining signal strength of radio-telemetry). Duration given was variable from 1 week to several years. Most animals were found using natural marking on the animal (which includes scars) (Table 7).

A release was generally seen as successful (Table 8) if released animals bred, or if certain percentage of animals remained alive after a certain time. Out of a released group, most rehabilitators said that any survival would constitute a success (Table 8), because “even if a few survive, it is at least saving the life of those few”. Most rehabilitators (52% of n = 23 who responded) felt that post-release time period in which to judge “success” was species dependent, resulting in a period between 1 week and >2 years.

Most rehabilitators did not know how many of their releases were successful or they thought that 75% of their releases were successful (Table 8). A successful release was described as mainly resulting from a suitable release habitat and having learnt lessons from past releases (Table 8), while unsuccessful releases were mainly caused by the animal being captive bred (or human-imprinted), it was the wrong time of year, and there was a lack of support from landowners (Table 8).

Finances

Most rehabilitation centres were financed using the rehabilitators’ own money, while public donations, private donor, and corporate sponsorship each accounted for less than 12% (Table 9). When asked to rank various expenditures, most of the money was spent on food for animals, while the least amount was spent on post-release monitoring (Table 9). When given a hypothetical large donation to spend on the same items as listed in the previous question, most said that they would use this money for animal housing; and the least amount would be spent on post-release support and monitoring (Table 9).

Comments

The comments given by the 35 respondents who wanted feedback or results from the survey, in general stated that they would like to see a network develop between rehabilitators, so that they can learn from each other without repeating the same mistakes; they also wanted to increase the success of rehabilitation by having it become more professional through standard methodology and having species-specialist centres; they also hoped for acknowledgement by their local governments in the work they were doing, while others wished for financial support from government or any other willing sponsor.

Discussion

Views were obtained from a range of rehabilitation centres across South Africa, from specialist centres dealing with a few animals a year, to large generalist centres that receive up to 3600 animals. Similarly, centres that started relatively recently and those in existence for many years were represented. In general, the results of the survey suggest that rehabilitators want their field to become more professional (through minimum standards and enforcement), but lack of communication between rehabilitators, lack of experience and empathy by government wildlife officials, and lack of money are the main obstacles to this being achieved. In the authors' opinion, these factors may result in the welfare of rehabilitated animals being compromised.

The perceived lack of experience and empathy of wildlife officials resulted in rehabilitators generally regarding their local government wildlife officials with antagonism, where they stated “unsuitable people are issued or re-issued permits” because “wildlife officers do not know enough about rehabilitation”. Dubois and Fraser (2003a,b) showed that Canadian rehabilitators voiced similar views, in particular: that the rehabilitation guidelines used by wildlife officials were of a low standard, that centres were not adequately inspected and reports of un-permitted or unethical rehabilitators were not addressed. It is then not surprising that rehabilitators are cautious of having these officials involved in the development and enforcement of minimum standards. Most rehabilitators believed that standards would be beneficial, but they were concerned with their practicality. One suggestion was to have experienced rehabilitators involved in the process of development. This seems to have worked for the development of the minimum standards in the USA (Miller 2000) and guidelines for raptor rehabilitation by the Western Cape Raptor Rehabilitation Forum (Curtis & Jenkins 2002). This forum includes representatives from rehabilitation centres, CapeNature, the SPCA, the local university, the Cape Falconry Club and local veterinarians and its aims were to form a network of skilled rehabilitators and veterinarians; to develop a protocol for raptor rehabilitation; and collate data from rehabilitated raptors (eg cause of injuries) (Curtis & Jenkins 2002). However, as these two documents are not enforced, it might explain their general “acceptance” by the rehabilitator community. Furthermore, when the author, KW, attended meetings discussing the “Norms and Standards for Care and Management of Ex Situ Vervet Monkeys *Cercopithecus aethiops* in KwaZulu-Natal”, it was clear that there were several disagreements within the rehabilitator community, such as the inclusion in the documents of advice of certain rehabilitators, over others. Similarly, rehabilitators in the survey stated that “rehabbers egos and personal agendas” would prevent minimum standards from being used, which echoed the view of some Canadian rehabilitators who would prefer to “do [their] own thing” (Dubois & Fraser 2003a). Clearly, there is a need for an inclusive forum to develop minimum standards, but it seems that without enforcement (by competent wildlife officers) these will be ignored. However, the enforcement of guidelines for euthanasia, the rehabilitation of non-native species, and the use of non-releasable wildlife, might be problematic, as these are seen as sensitive and contentious issues in wildlife rehabilitation (Holcomb 1995; Dubois & Fraser 2003b).

In Canada, the veterinarians that were surveyed believed that rehabilitators were generally reluctant to euthanase (Dubois & Fraser 2003b). It seems that the situation is similar in South Africa, as there was a preference of South African centres to place non-releasable animals in captivity at a sanctuary or retain at the centre for education, breeding, or surrogacy purposes rather than to euthanase them. When seen in light of the goals of rehabilitation, namely “caring and helping of injured, ill and orphaned animals”, “ releasing animals back into the wild” (Table 2; Anon 2008a), and “educating the public to prevent these problems in the future” (Table 2; Dubois & Fraser 2003a), there does seem to be a need for non-releasable animals as surrogate mothers or for education. However, the build up of non-releasable animals in captivity, “zoos under the guise of public education” (Dubois & Fraser 2003b), may be harmful to animal welfare (Curtis & Jenkins 2002). Conversely guidelines for determining whether an animal can be released should not be less stringent in an attempt to avoid euthanasia (Hall 2005) or to reduce the numbers in captivity. Releasing animals that are unprepared for life in the wild may result in needless suffering and death (Waples & Stagoll 1997; IUCN 2000; Hall 2005). In essence, rehabilitators could be needlessly causing suffering, in spite of their best intentions. As a result, minimum standards and enforcement are needed for decisions regarding the use of non-releasable animals and rehabilitation of exotics. For decisions regarding euthanasia, it would be best to have a veterinarian or veterinary nurse based permanently at the centre. A veterinarian and veterinary nurse are also qualified to determine whether an animal is healthy (during care or before release), which would lesson possible welfare issues and well as the probability that a diseased individual is released into the wild.

Preparing and determining whether an animal is ready for release have been described in various guidelines; means of doing this include whether the animal is healthy (IUCN 1998; Baker 2002) and has regained fitness (Verdoorn 1995; Miller 2000; Hall 2005). This was similar to that described by rehabilitators, but they also included factors such as “interspecies communication”, and knowing when an animal is fit for release “from experience” and “if it leaves”. In addition, even with universal methods, limited research has been done to determine whether these preparations or characteristics are the most effective predictors of survival post-release. Exceptions, such as those on the benefits of live prey and flight aviaries on rehabilitated barn owls (*Tyto alba*) (Fajardo et al. 2000); and the potential of various physical (eg weight) (Mathews et al. 2006) and psychological characteristics (eg human imprinting) (Beringer et al. 2004) as predictors of survival post-release, need to be assimilated into minimum standards for rehabilitation. These standards should also incorporate the results from other translocation studies, such as re-introductions (ie establishing a species in an area it used to exist, IUCN 1998). This literature includes results on training captive-bred animals to avoid predators (see review by Griffin et al. 2000), and which factors (eg habitat suitability) resulted in successful releases (Griffith et al.

1989). Similar success factors were identified by rehabilitators and included "learning from previous releases", which would entail post-release monitoring. Although 68% of the rehabilitators had done some monitoring, it is clearly not a priority as rehabilitators currently and hypothetically would spend the least amount of money on post-release monitoring. Minimal post-release monitoring due to limited funding has also been documented in Spain (Fajardo et al. 2000), England (Kirkwood & Best 1998) and Canada (Dubois & Fraser 2003c). In summary, even though there is a need for high-quality empirical data from scientific investigations to objectively support the clearly defined objectives of wildlife rehabilitation, it is undermined by a lack of funding.

Lack of funding was cited as a main impediment to the goals of rehabilitation in South Africa, mirroring the answer by Canadian rehabilitators (Dubois & Fraser 2003a). Food and housing for animals were listed as main expenditures by South African rehabilitators, while housing and repairs to housing as priority expenditures if given a donation. Listing "repairs to housing" in the latter question suggests that this is a luxury expenditure compared to the more urgent need of feeding animals, which may have implications on animal welfare. This problem is likely due to large numbers of animals being admitted to the centre, as well as home-based centres unable to obtain necessary funding. Some solutions would be to have a centre specialise in a certain taxon or species, limit the number of animals admitted according to the space that is available at the centre (and so transfer to other centres or euthanase), and have home-based centres linked to larger centres. For instance, a rehabilitator specialising in raptors may get 36 animals admitted over two years (Visagie 2008), compared with a non-specialist receiving over 2000 animals (Dubois & Fraser 2003c), where based on their resources and space, it may not be possible to provide adequate and humane care to all and adequate preparation for release. Without norms and standards, lack of funding could result in serious animal welfare issues, if poorly staffed and equipped rehabilitation centres are allowed to continue to operate.

Furthermore, a lack of funding limits rehabilitators from determining whether a release has been successful, and whether modifications in rehabilitation techniques are needed (Beck et al. 1994; Lockwood 1995; Kleiman 1996; Hall 2005) as they generally do not monitor rehabilitated animals after release. However, because any survival out of a released group was seen as a success, echoing the sentiment that "these animals would almost certainly have died were it not for human intervention" (Reeve 1998, p200), or that survival of young wild animals reaching reproductive maturity is generally low (Kirkwood 2000), it may not seem important to monitor. Conversely, were it not for human intervention those individuals would not have had to go through stress and fear of captivity and possible pain of healing (BWRC 1989 in Kirkwood 1992). It is, therefore, imperative to ensure that a successfully rehabilitated animal be at no greater disadvantage to living in the wild than its wild conspecifics of similar age, gender and status (IAAWS 1992), which is at a basic level determined by survival of the released individual. Similarly, improved welfare of a released individual must not compromise the welfare of other individuals living in the release habitat (Kirkwood & Sainsbury 1996). Maximising welfare for all animals may be achieved through improved communication between rehabilitators and wildlife officials and a better management framework for wildlife rehabilitation.

Even though the conservation department in government wants to ensure biodiversity is unharmed and protected, it has largely ignored wildlife rehabilitation, except by issuing and revoking permits in an attempt to control these practices. This involvement is not enough, mainly for two reasons. Firstly, according to the IUCN

(2000) the release of confiscated animals (which applies to rehabilitated animals) should generally not take place, expect in specially managed circumstances, because of the possible negative affects on wild conspecifics living in the area (Caldecott & Kavanagh 1983; Griffith et al. 1993; Kleiman 1996; IUCN 2000), and on entire wildlife communities. Wildlife rehabilitation has thus moved from a practice that affects individual survival to affecting conservation. Secondly, conservation agencies need to value rehabilitation, since rehabilitators are relieving the government of additional responsibility, given that the management of all wild animals is part of their mandate (Carr 1995); and rehabilitation may actually get the public interested in conservation, through education and empathic response to addressing the plight of an afflicted individual (as reviewed by Kirkwood 1992; Aitken 2004). Rehabilitation of endangered individuals even has direct conservation benefits (Kirkwood 1993). Exploring this common ground between wildlife rehabilitators and wildlife officials has been started by EKZNW in South Africa, while similar documents (eg Miller 2000; Anon 2008b) may provide a base for this exploration elsewhere in the world. This co-operation is certainly possible, but through both parties being objective and considerate of each other's needs, and to persevere in this effort, as the alternative may be to ban wildlife rehabilitation all together. South Africa may be ready for the second national Wildlife Rehabilitation Conference to be held, in an attempt to explore this co-operation further.

Animal welfare implications

Wildlife rehabilitation satisfies the natural desire of some humans to rescue animals in distress (Lloyd 1999) and to counterbalance the harm that humans have caused (Jacobs 1998; Kirkwood & Best 1998; du Toit 1999). Unfortunately, this does not always mean that the animals benefit. Limited research on the best methods of preparing or deciding whether an animal of a particular species is ready for release, and limited post-release monitoring, means that these decisions are largely based on intuition. Furthermore, rehabilitators in this study and in Canada knew of other rehabilitators that were providing inadequate care to animals (Dubois & Fraser 2003b). For these reasons, the authors' suggest that rehabilitation in South Africa (and possibly throughout the world) needs to become the responsibility of government, so that lack of finances, knowledge, and experience, together with lack of communication and co-operation between rehabilitators do not get in the way of animal welfare. It is also suggested that the control of wildlife rehabilitation be centralised at national or provincial level in government, where at least one or more people (per province in South Africa) are designated and trained to implement this, perhaps with the help of wildlife-or conservation-orientated non-governmental organisations (NGO). It is imperative that minimum standards are enforced by competent, knowledgeable conservation officers in government or hired from private NGOs, otherwise animal welfare may be compromised, and rehabilitators are unlikely to co-operate with regulations. In addition, as attempted by EKZNW and by the private rehabilitation organisations in the USA (IWRC and NWRA) completion of certification programmes in wildlife rehabilitation need to be enforced. In return, the government needs to subsidise the post-release monitoring of rehabilitated wildlife, as post-release monitoring is the only method to determine whether rehabilitation of an individual was successful. On a basic level this means survival of the released individuals that is similar to that observed in the wild. EKZNW initiated the post-release monitoring of rehabilitated vervet monkeys (Chapter 3), so that the results could be used as a benchmark for future releases by inclusion in the Norms and

Standards for the Care and Management of Ex Situ Vervet Monkeys *Cercopithecus aethiops* in KwaZulu-Natal. EKZNW also initiated the post-release monitoring of rehabilitated Babcock's leopard tortoises, *Stigmochelys pardalis babcocki* (Chapter 5), to test a EKZNW release protocol that aims to increase the probability that the release of rehabilitated leopard tortoises is successful, while minimising risks to biodiversity. Not only could conservation scientists be involved in the post-release monitoring, but they could also conduct further research into which preparations and characteristics are most likely to predict survival of rehabilitated animals post-release. Furthermore, both conservation scientists and wildlife officials could analyse annual intake records from centres for trends that may be useful for conservation efforts (Drake & Fraser 2008). Rehabilitators could then focus their money on buying food, housing and medicines, so that they can continue to serve the community by rehabilitating individual wild animals.

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Table 1: Number of centres in each province, how long they have been in existence and answers by rehabilitators to where their centre is based. Note that some rehabilitators were based out of more than one centre, such that the number given for this question is not representative of the number of rehabilitators ("n"), but how many times an option was selected ("S").

Question	Options given in the questionnaire (a-m) or additional answers given	%	n
1) Number of centres in each province (n=63)	Eastern Cape	6	4
	Free State	5	3
	Gauteng	17	11
	KwaZulu-Natal	32	20
	Limpopo	11	7
	Mpumalanga	2	1
	North West	5	3
	Northern Cape	2	1
	Western Cape	21	13
2) Number of years centre has been in existence (n=38)	1-5 years	34	13
	6-15 years	39	15
	16-25 years	18	7
	26-40 years	8	3
3) Location of centres (n=39)	a) Small holding	30	13
	b) Private home	37	16
	c) Municipal land	7	3
	d) Other*	26	11
	*Additional answers: game reserve, farm, private landholding (eg wine estate)		

Table 2: Answers by rehabilitators to questions on goals and impediments to wildlife rehabilitation, minimum standards and permit conditions. Note that as a result of there being no limitations on the number of times an option could be selected, the column "S" refers to the number of times each rehabilitator ("n") selected an answer.

Question		Options given in the questionnaire (a-m) or additional answers given	%	S
1) Goals of wildlife rehabilitation? (n=41)		a) Caring and helping of injured/orphaned wild animals	23	36
		b) Manage interaction between animals and people	13	20
		c) Education to prevent these problems in the future	19	29
		d) Releasing animals back into the wild	24	37
		e) Wildlife conservation	17	26
		f) Other*	4	6
		*Additional answers eg animals away from untrained people; captive breeding and release of endangered reptiles		
2) Main problems in obtaining these goals? (n=41)		a) Lack of money for facilities/supplies/staff	17	29
		b) Lack of trained staff	6	11
		c) Lack of government support and subsidy	11	20
		d) Inadequate media coverage	5	9
		e) Public picking up animals unnecessarily	13	22
		f) Public keeping wild animals irresponsibly	14	24
		g) Lack of knowledge of post-release survival	6	11
		h) Lack of norms and standards for rehabilitation centres	6	10
		i) Strict permit conditions	6	11
		j) Lack of available release habitat	8	14
		k) High post-release mortality	2	3
		l) Lack of research	5	9
		m) Other*	1	5
		*Additional answers eg legislation not supportive, seemingly no need for us, too many animals coming in, lack of harmony with rehabbers		
3) Minimum standards	Reasons for (n=20)	Ignorance results in unprofessional and inhumane rehabilitation (eg species treated incorrectly, inadequate disease control)	54	13
		Standardise procedures from all centres (brings new ideas, information is shared) and make decisions easier	25	6
		Lower morbidity and mortality of releases (eg ensuring released in right areas)	13	3
		People with wrong agenda (eg hoarders) prevented from rehabbing	8	2
	Reasons against (n=13)	Most people have/should have this knowledge and doing a good job within their limitations	24	4
		Problem is who establishes the standards (need experienced rehabbers who understand the constraints)	24	4
		Not enough wildlife officials to monitor and they are not experienced (they need guidelines)	18	3
		It won't work because of rehabbers egos and own agendas	12	2
		Guidelines but not enforcement, because of costs involved and subjective issues (eg euthanasia)	12	2
		It won't work because each species would need its own guideline	12	2
4) Permits are not being enforced properly/ are a hindrance (n=26)		Unsuitable people are issued/re-issued permits, do not notice if don't comply, because wildlife officers do not know enough about rehabilitation	26	9
		Not enough officers/impractical to enforce, not inspected frequently enough	12	4
		Permit conditions inappropriate/impractical/too general	21	7
		Too many people (especially public) have wild animals without permits	9	3
		Well established rehabbers are continuously harassed	6	2
		Other (eg personal agendas in permit office, conservation act not strong enough, different rules apply to different species, not focussing on animal traders/zoos)	26	9

Table 3. List of animals given by rehabilitators when asked to list five common species coming in to their centres, where the column "S" lists the number of centres (out of n = 39) who listed the species.

Animal class	Order/group	Animals included (Common name, Family name)	%	S
Mammal	Order Hyracoidea	Rock Hyrax (Procaviidae)	1	1
	Order Lagomorpha	Scrub hare (Leporidae)	3	2
	Order Rodentia	Porcupine (Hystricidae)	4	3
	Order Primates	Galago (Galagidae), Chacma baboon (Cercopithecidae), Vervet monkey (Cercopithecidae)	26	20
	Order Chiroptera	Bat (Various)	3	2
	Order Carnivora	Gennet, Civet (Verridae); Mongoose, Suricate (Herpestidae); Jackal, Wild dog (Canidae); Otter (Mustelidae); African wild cat, Black-footed cat, Cheetah, Leopard, Lion (Felidae)	33	25
	Order Erinaceomorpha	Hedgehog (Poaceae)	8	6
	Order Ruminata	Bushbuck, Reedbuck, Duiker (blue and grey) (Bovidea)	20	15
	Unknown	Unknown species of mammals	3	2
Bird	Unknown	Unknown species of birds	18	9
	Garden birds	Doves (Columbidae, order Columbiformes), Hadeda ibis (Threskiornithidae, order Ciconiiformes)	14	7
	Water birds	Geese, duck (Anatidae, order Anseriformes)	6	3
	Owls	Spotted eagle owl, wood owl (Strigidae), barn owl (Tytonidae) (all order Strigiformes)	22	11
	Crow	Corvidae, order Passeriformes	2	1
	Raptors	Eagles, Hawks, Kite (yellow-billed, black-shouldered), Goshawk, Buzzard, Vulture (Accipitridae), Secretary bird (Sagittariidae), Falcons, Kestrel (Falconidae) (all order Falconifornes)	35	18
	Sea birds	Cormorant (Phalacrocoracidae), Penguin (Spheniscidae) (both order Ciconiiformes)	4	2
Reptile	Reptiles	Unknown species	13	3
	Order Chelonia	Terrapin (Pelomedusidae) and Tortoise (Testudinidae)	30	7
	Order Squamata, Sub-order Serpentes	Snake (Various)	26	6
	Order Squamata, Sub-order Sauria	Chameleon (Various), Monitor (Various), Lizard (Various)	26	6
	Order Crocodylia	Crocodile (Crocodylidae)	4	1
Amphibian	Order Anura	Frog (Various)	n/a	1

Table 4. Answers by rehabilitators to questions on the species rehabilitated, fate of non-rehabilitated species, the presence of a veterinarian, health checks conducted at the centre and quarantine policy. Note that as a result of there being no limitations on the number of times an option could be selected, the column "S" refers to the number of times each rehabilitator ("n") selected an answer.

Question	Options given in the questionnaire (a-i) or additional answers given	%	S
1) Reason for your centre not rehabilitating all species (n=34)	We are a specialist centre (eg because increase chance of survival, it is a permit condition)	38	14
	The centre does not have the capacity (eg for large mammals)	30	11
	Rather send to specialists (eg because have experience)	19	7
	Do not rehabilitate exotic species	11	4
	Not allowed to release tortoises after rehabilitation [provincial government stance]	3	1
2) How do you deal with species that you do not rehabilitate? (n=37)	a) Accept and transfer to another rehabilitation centre	64	30
	b) Accept and euthanse these animals	9	4
	c) Do not accept and refer to another rehabilitation centre	28	13
3) Do you have a veterinarian at your centre? (n=38)	a) Yes-permanently	8	3
	b) No	71	27
	c) Sometimes	21	8
4) What health/disease checks do you do? (n=34)	Feather/skin/coat condition	8	6
	Disease (eg salmonella, trichomoniasis, mange)	15	11
	Parasites (internal and external)	28	21
	Psychological (eg changes in behaviour, lethargy)	7	5
	Body condition (including weight, any injuries)	16	12
	Stools (eg if diarrhoea)	8	6
	Appetite	7	5
	If recovering from treatment	4	3
	Other (eg deworming, check for bumble foot, condition of teeth, veterinarian does check)	7	5
5) Under what circumstances do you quarantine? (n=31)	On arrival	54	19
	When disease suspected	29	10
	On advice from veterinarian	14	5
	Permit condition	3	1

Table 5. Answers by rehabilitators to questions on non-releasable animals and criteria for euthanasia. Note that as a result of there being no limitations on the number of times an option could be selected, the column "S" refers to the number of times each rehabilitator ("n") selected an answer.

Question	Options given in the questionnaire (a-i) or additional answers given	%	S
1) When would you not release an animal into the wild (n=18)	a) It is an exotic species	20	18
	b) There is no suitable habitat for release	15	13
	c) It is blind/deaf	18	16
	d) It only has 1 leg/ 1 wing	18	16
	e) It cannot walk/fly	17	15
	f) Other*	11	10
	*Additional answers: imprinted/humanised, endangered species (for breeding)		
2) If an animal cannot be released into the wild, do you: (n=34)	a) Euthanase	20	18
	b) Transfer to a sanctuary or zoo	26	23
	c) Give to permit-keeping members of the public	8	7
	d) Kept at your centre for education purposes	18	16
	e) Kept at your centre for breeding purposes	11	10
	f) Kept at your centre for rearing young	13	11
	g) Other*	3	3
	* Additional answers: other breeding programmes, falconry		
3) If your centre euthanases animals, when would you do this? (n=38)	a) When the animal has non-repairable injuries	50	34
	b) There are no resources to care for the animal	1	1
	c) The animal is an exotic species	4	3
	d) The animal is a common species	0	0
	e) The animal is in poor condition	4	3
	f) Problem animals	4	3
	g) Potentially diseased	15	10
	h) Heavily infested with ecto- and endo-parasites	1	1
	i) Other*	19	13
	*Additional answers: untreatable/infectious disease, no chance at having a pain free life, will not have good quality life, vets recommendation, injured common species		
4) If your centre does not euthanase, what is the reason? (n=6)	a) Public opinion	0	0
	b) Centre's policy	67	4
	c) Permit regulations	0	0
	d) Funding sources	0	0
	e) Lack of resources to perform euthanasia	33	2
	Comment b): It is our last resort		
	Comment e): Veterinarian euthanases		

Table 6. Answers to questions on how rehabilitators prepare an animal for release and judge whether an animal is fit enough. Note that as a result of there being no limitations on the number of times an option could be selected, the column "S" refers to the number of times each rehabilitator ("n") selected an answer.

Question	Answers given	%	S
1) How do you prepare an animal for release? (n=31)	Placed in different pen to live (mimic release environment, bigger, natural)	20	10
	Get them fit eg by falconry, flight cage, forced to swim	18	9
	Break bond with human (eg reduce contact, correct socialisation)	12	6
	Soft release	12	6
	Receive indigenous food	8	4
	Healthy	8	4
	Transferred to another centre who releases	6	3
	Live trained	6	3
	Depends on species	6	3
	Interspecies communication	4	2
	Nothing really	2	1
2) What characteristics do you use to judge whether an animal is fit for release? (n=41)	Able to fend for itself in wild (eg anti-predator behaviour, foraging efficiently)	23	24
	Healthy (esp. good body mass, no parasites)	21	22
	Flying/walking properly (incl. wounds/injuries healed)	12	13
	Not imprinted/humanised/socialises correctly with conspecifics	11	12
	Fit enough (eg judged using falconry)	10	11
	Behaviour/psychological health (eg if alert)	7	7
	Good muscle/coat/feather condition	4	4
	Good cohesion of group	3	3
	From experience	3	3
	Old enough	3	3
	Get go ahead from vet	2	2
	It will leave site	2	2

Table 7. Answers by rehabilitators on post-release monitoring. Note that as a result of there being no limitations on the number of times an option could be selected, the column "S" refers to the number of times each rehabilitator ("n") selected an answer.

Question	Options given in the questionnaire (a-k) or additional answers given	%	S
1) Reasons for monitoring (n=11)	Whether the rehabilitation technique was successful (eg animal is not human-imprinted, injuries have healed)	77	10
	Monitor movement (eg if problem animals return to original site)	15	2
	It is the established norm for the species	8	1
2) If not currently doing so, would you start to monitor if you had (n=12):	a) More money for monitoring equipment/petrol to get to sites/staff to monitor	38	6
	b) Knew more about how and what to monitor to determine whether a release was a success	31	5
	c) Other*	31	5
	*Additional answer: No		
3) How do you find and identity the animals you release? (n=29)	a) Natural markings on the animal	33	20
	b) Markings placed onto the animal (eg ear tags/ freeze branding)	31	19
	c) Radio-telemetry (on collars/harnesses)	18	11
	d) I just know when I see the animal	18	11
	e) Other	0	0

Table 8. Answers by rehabilitators on success indicators. Note that as a result of there being no limitations on the number of times an option could be selected, the column "S" refers to the number of times each rehabilitator ("n") selected an answer.

Question	Options given in the questionnaire (a-k) or additional answers given	%	S
1) What would constitute a successful release? (n=35)	a) Certain % of animals remain alive after a certain time	35	27
	b) Released animals breed successfully	36	28
	c) Released animals stay in one area	13	10
	d) Other*	16	12
	*Additional answer: successfully integrated into wild, feed successfully		
2) How many out of a released group survive for a success? (n=32)	a) 100%	9	3
	b) 75%	34	11
	c) 50%	16	5
	d) Any survival	41	13
3) What % of your releases were successful? (n=36)	a) 100%	14	5
	b) 75%	19	7
	c) 50%	8	3
	d) 25%	6	2
	e) I don't know-we don't do any post-release monitoring	31	11
	f) Depends on species	17	6
	Additional answer: 80-90%	6	2
4) What factors resulted in the successful releases? (n=30)	a) Age of animal	12	19
	b) Wild bred	12	19
	c) If applicable: age and sex structure of the group	7	12
	d) Soft release (supplementary feeding and/or holding cage)	10	16
	e) Hard release	4	7
	f) Time of year i.e. Food and water availability	13	21
	g) Suitable habitat	15	24
	h) Good support of landowners	11	17
	i) Lessons learnt from previous releases	14	22
	j) Other*	2	4
	*Additional answers: initial disease/injury, individuals released back to troop		
5) What factors resulted in the unsuccessful releases? (n=26)	a) Age of animal	11	12
	b) Captive bred**	14	15
	c) If applicable: age and sex structure of the group	6	6
	d) Soft release (supplementary feeding and/or holding cage)	3	3
	e) Hard release	7	7
	f) Time of year i.e. Food and water availability	13	14
	g) Unsuitable habitat	11	12
	h) No support from landowners	13	14
	i) First release of this animal species	8	8
	j) Natural disaster (eg flood/drought)	10	11
	k) Other*	4	4
	*Additional answers: illegal hunting, number of predators in area		
	**Included if human-imprinted		

Table 9. Funding sources and expenditure of rehabilitators ("n") from their annual budget and hypothetical expenditure of a large donation, where expenditure is ranked from 1 (spend most on) to 10 (spend least on).

Question	Options given in the questionnaire (a-j) or additional answers given	N (mean ± SE)	N (median)	Range
1) Funding (n=36)	a) Public donations	11 ± 3 %	N/a	0-50
	b) Private donor	10 ± 3 %	N/a	0-60
	c) Corporate sponsorship	3 ± 1 %	N/a	0-25
	d) Government subsidy	0	N/a	0
	e) Own money	76 ± 6 %	N/a	0-100
2) Budget (n=32)	a) Food for animals		2	1-10
	b) Housing of animals, esp. lights and electricity		3	1-10
	c) Repairs to housing		5	2-10
	d) Veterinary procedures		4	1-10
	e) Equipment		6	1-10
	f) Staff salary		4	1-10
	g) Release of animals-transport		7	2-10
	h) Post-release support (food/shelter)		9	2-10
	i) Post release monitoring		10	3-10
	j) Rescues		5	1-10
3) Donation (n=30)	a) Food for animals		4	1-10
	b) Housing of animals, esp. lights and electricity		2	1-8
	c) Repairs to housing		3	1-10
	d) Veterinary procedures		6	1-10
	e) Equipment		3	1-10
	f) Staff salary		8	1-10
	g) Release of animals-transport		7	2-10
	h) Post-release support (food/shelter)		8	2-10
	i) Post release monitoring		8	1-10
	j) Rescues		6	1-10

Appendix 1. Questionnaire

Name of the Rehabilitation Centre:
Year centre was established:
Permit no.:
Web URL (homepage):
Your name:
Your role at the centre:

<u>Section A: General</u>

1. According to your centre, what are the goals of wildlife rehabilitation?
[a] Caring and helping of injured/orphaned wild animals
[b] Manage the interaction between animals and people
[c] Education to prevent these problems in the future
[d] Releasing animals back into the wild
[e] Wildlife conservation
[f] Other (please specify below):

2.According to your centre, what are the main problems in obtaining these goals?
[a] Lack of money for facilities/supplies/staff
[b] Lack of trained staff
[c] Lack of government support and subsidy
[d] Inadequate media coverage
[e] Public picking up animals unnecessarily
[f] Public keeping wild animals irresponsibly
[g] Lack of knowledge of post-release survival
[h] Lack of norms and standards for rehabilitation centres
[i] Strict permit conditions
[j] Lack of available release habitat
[k] High post-release mortality
[l] Lack of research
[m] Other (please specify below):

3. Do you think that rehabilitation centres would benefit from guidelines for minimum standards for wildlife rehabilitation e.g. standards for cleaning, disease control, caging, euthanasia, release criteria and record keeping?
[a] Yes
[b] No

Please provide a reason:

4. Do you think that the issuing and enforcement of permits is:
[a] important and functioning correctly
[b] could be important, but is not being enforced properly and permit conditions are not strict enough
[c] not useful and even a hindrance to doing rehabilitation

Please provide a reason:

Section B: Animal Intake

5. What is your approximate annual intake of animals (mammals, birds and reptiles)?

6. Please list 5 main causes that result in animals being brought to your centre:

7. Do you mark (e.g. with numbered rings) the animals that you get into the Centre?
[a] Yes
[b] No
[c] Sometimes

Please provide a reason:

If applicable, how do you mark the animals?

8. Besides marking (if applicable), what are the other first steps that are taken when an animal is admitted to your Centre?

9. a) Are there any animal species that your centre does **not** rehabilitate?
[a] Yes
[b] No, we accept and treat all species

If you answered "yes", please list the species and please provide a reason:

9. b) What are the 5 main animal species that you get into your centre

9. c) How do you deal with species that you do not rehabilitate?

[a] Accept and transfer to another rehabilitation centre (please specify below)
[b] Accept and euthanase these animals
[c] Do not accept and refer to another rehabilitation centre (please specify below):

10. a) When would you NOT release an animal into the wild:
[a] it is an exotic species
[b] there is no suitable habitat for release
[c] it is blind/deaf
[c] it only has 1 leg/ 1 wing
[d] it cannot walk/fly
[e] other (please specify below):

10. b) If an animal cannot be released into the wild, do you:
[a] euthanase
[b] transfer to a sanctuary or zoo
[c] give to permit-keeping members of the public
[d] kept at your centre for education purposes
[e] kept at your centre for breeding purposes
[f] kept at your centre for rearing young
[g] other (please specify below):

11. If you keep non-releasable animals at your centre, please specify which species and your reasons why this species:

12. If your centre euthanases animals, when would you do this?
[a] When the animal has non-repairable injuries
[b] There are no resources to care for the animal
[c] The animal is an exotic species
[d] The animal is a common species
[e] The animal is in poor condition
[f] Problem animals
[g] Potentially diseased
[h] Heavily infested with ecto- and endo-parasites
[i] Other (please specify below):

13. If your centre does not euthanase animals, which of the following are applicable reasons:
[a] Public opinion
[b] Centre's policy
[c] Permit regulations
[d] Funding sources
[e] Lack of resources to perform euthanasia

14. Do you have a veterinarian at your Centre?
[a] Yes-permanently
[b] No
[c] Sometimes

Please can you provide her/his name:

15. Do you do any ongoing health/disease checks on the animals at your Centre?
[a] Yes
[b] No
[c] Sometimes

If you answered "yes" or "sometimes", what do you check for?

16. Do you have a quarantine policy?
[a] Yes
[b] No

If you answered "yes" under what circumstances (e.g. always on arrival)?

Section C: Records

17. How many years has your centre been keeping records?

18. a) Does your facility record information of ALL animals coming in?
[a] Yes
[b] No

18. b) If you answered “no”, what is the reason?
[a] Too many animals coming in
[b] It isn’t important for some animals
[c] Time is wasted and records are not even used
[d] Other (please specify below):

19. a) What information do you record?
[a] General name of the animal (e.g. tortoise)
[b] Species of animal (e.g. leopard tortoise)
[c] History of animal given by the person bringing it in
[d] Location of animal given by the person bringing it in
[e] Diagnosis of animal brought in
[f] Individual medical records
[g] Where the animal is placed at centre
[h] Date and location of released animal
[i] If the animal has died at the centre
[j] If the animal has been transferred to another facility
[k] Other (please specify below):

19. b) Which species don’t you maintain post-admittance records for and why?

20. Do you think that your centre can make improvements to its recording system and/or the way it processes the data from the records?
[a] Yes
[b] No

Please provide a reason:

Section D: Housing

21. Where is your rehabilitation centre situated?
[a] Small holding
[b] Private home
[c] Municipal land
[d] Other (please specify below):

22. Do you have multi-species enclosures (e.g. hadedas and doves in one cage)?
[a] Yes
[b] No
[c] Sometimes

Please provide a reason:

23. Do you separate animals according to gender?
[a] Yes
[b] No
[c] Sometimes

Please provide a reason:

24. Do you separate animals according to age?
[a] Yes
[b] No

Please provide a reason:

25. Do you have any other criteria that you use to separate animals?
[a] Yes
[b] No

Please provide a reason:

Section E: The Release

26. How do you prepare an animal for release (e.g. placed in different pen)?

27. Do you sterilise any animals before they are released?
[a] Yes
[b] No

Please provide a reason:

28. What characteristics do you use to judge whether an animal is fit for release (e.g. looks healthy)?

29. How do you choose a suitable release site?
[a] The area is within the normal range of the species
[b] Close to where the animal came from
[c] Away from humans
[d] Where the animal will be accepted by the landowners
[e] Suitable habitat for the species
[f] Other (please specify below):

30. Do you soft-release **all** the animals at your Centre? (i.e. keeping animal in holding cage at release site and/or supplementary feeding after release for a period of time). If not, please proceed to question 33.
[a] Yes
[b] No

If you do it for some species only, please provide the name of the species and reason:

31. a) If you use a **holding/hacking cage** to release an animal into the wild, do you do it because it:
[a] keeps the animal in the release area
[b] if applicable, it keeps the group of released animals together
[c] allows it to adjust from stress of transport
[d] allows it to adjust to new sights/sounds/smells of release area
[e] its in guidelines that we have
[f] other (please specify below):

31. b) Do you keep all species in the holding cage for the same time period?
[a] Yes
[b] No

An average, for how long?

31. c) What are the factors you think should be taken into consideration when determining how long the animal should be kept in holding cage for?
[a] Whether species is solitary or social
[b] Whether species is mammal/bird/reptile
[c] Whether species is predator/prey
[d] Whether animal is healthy
[e] How long the animal had been in captivity for
[f] Other (please specify below):

32. a) If you **supplementary feed** an animal after release, do you do it because it:
[a] keeps the animal in the release area
[b] if applicable, it keeps the group of released animals together
[c] allows the animal to get used to the indigenous vegetation in area
[d] eases the adjustment to being outside of captivity
[e] its in guidelines that we have
[f] other (please specify below):

32. b) Do you supplementary feed all species for the same time period?
[a] Yes
[b] No

An average, for how long?

32. c) What are the factors you think should be taken into consideration when determining how long the animal should be supplementary fed?
[a] whether species is solitary or social
[b] whether species is mammal/bird/reptile
[c] whether species is predator/prey
[d] how healthy the animal is
[e] how long the animal had been in captivity for
[f] other (please specify below):

33. If it is relevant, why do you hard release some animals (i.e. no holding cage at release or supplementary feeding after)?
[a] less expensive than soft-release
[b] the animals do not need to be soft-released
[c] to lesson their reliance on humans
[d] other (please specify below):

Section F: Post-Release

34. a) Do you monitor animals after they have been released?
[a] Yes
[b] No

If you answered “yes”, which species do you monitor and why?

34. b) If you answered “no”, would you begin monitoring if you had:
[a] more money for monitoring equipment/petrol to get to sites/staff to monitor
[b] knew more about how and what to monitor to determine whether a release was a success
[c] other (please specify below):

35. Does the time period for post-release monitoring vary between species?
[a] Yes
[b] No

An average, for how long?

36. How do you find and identity the animals you release?
[a] Natural markings on the animal
[b] Markings placed onto the animal (e.g. ear tags/ freeze branding)
[c] Radio-telemetry (on collars/harnesses)
[d] I just know when I see the animal
[e] Other (please specify below):

If applicable, please specify the markings you use:

37. What do you record once you have found the animal?
[a] Whether animal is alive/dead
[b] Its behaviour
[c] What it is eating
[d] Its location
[e] Other (please specify below):

38. What would constitute a successful release?
[a] Certain % of animals remain alive after a certain time
[b] Released animals breed successfully
[c] Released animals stay in one area
[d] Other (please specify below):

39. a) How many animals out of a released group would have to survive for the process to be considered a success?
[a] 100%
[b] 75%
[c] 50%
[d] Any survival

39. b) Would you take the species of the animal into consideration when judging how many animals have to survive for the process to be considered a success?
[a] Yes
[b] No

Please provide a reason:

39. c) Would you take the age of the animal into consideration when judging how many animals have to survive for the process to be considered a success?
[a] Yes
[b] No

Please provide a reason:

40. Does the time period after which you consider a release to be successful vary between species?
[a] Yes
[b] No

An average, for how long?

41. On average what percentage of your releases do you consider to be successful? If you don't know please indicate.
[a] 100%
[b] 75%
[c] 50%
[d] 25%
[e] I don't know-we don't do any post-release monitoring
[f] Depends on the species (please specify below):

42. What factors resulted in the successful releases?
[a] Age of animal
[b] Wild bred
[c] If applicable: age and sex structure of the group
[d] Soft release (supplementary feeding and/or holding cage)
[e] Hard release
[f] Time of year i.e. Food and water availability
[g] Suitable habitat
[h] Good support of landowners
[i] Lessons learnt from previous releases
[j] Other (please specify below):

43. What factors resulted in unsuccessful releases?
[a] Age of animal
[b] Captive-raised
[c] If applicable: age and sex structure of the group
[d] Soft-release (supplementary feeding and/or holding cage)
[e] Hard-release
[f] Time of year i.e. Food and water availability
[g] Unsuitable habitat
[h] No support from landowners
[i] First release of this animal species
[j] Natural disaster (e.g. flood/drought)
[k] Other (please specify below):

Section F: Finance

44. How much of your annual funding comes from the following (please provide a relative percentage % or actual value):
[a] Public donations
[b] Private donor
[c] Corporate sponsorship
[d] Government subsidy
[e] Own money

45. Is some of your funding restrictive (e.g. donated money only used for certain species/staff funding)?
[a] Yes
[b] No

Please provide a reason:

46. How much of your current annual budget is spent on the following items? Please rank the following in order from 1-10 (1=spend most on, 10=spend least on):
[a] Food for animals
[b] Housing of animals, esp. lights and electricity
[c] Repairs to housing
[d] Veterinary procedures
[e] Equipment
[f] Staff salary
[g] Release of animals-transport
[h] Post-release support (food/shelter)
[i] Post release monitoring
[j] Rescues

47. If you were given a large donation, how would you spend this money? Please rank the following in order from 1-10 (1=spend most on, 10=spend least on):
[a] Food for animals
[b] Housing of animals, esp. lights and electricity
[c] Repairs to housing
[d] Veterinary procedures
[e] Equipment
[f] Staff salary
[g] Release of animals-transport
[h] Post-release support (food/shelter)
[i] Post release monitoring
[j] Rescues

Section G: Lastly

48. What feedback and/or results would you like from this survey and/or comments?

CHAPTER 3

Annual intake trends of a large urban animal rehabilitation centre in South Africa: a case study

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Abstract

Worldwide, each year, large numbers of wild animals are taken to rehabilitation centres for treatment, care and release. Although analysis of intake records may provide valuable insight into the threats and impacts to wildlife, there are few such published reports. Four-years of intake records from a large urban rehabilitation centre in South Africa were examined for trends. Animal intake rate was high (2701 ± 94 per annum). Most of the intake (90%) was birds, with few mammals (8%) and reptiles (2%), and most of these were of locally common species (eg doves, pigeons). This reflects the findings of other studies, namely that species living in close association with humans are the most frequently admitted to rehabilitation centres. In total, most of the animals admitted (43%) were juveniles, which were assumed to be abandoned or orphaned. The implications of then rehabilitating these juveniles, which were largely uninjured, is whether humans should be interfering with nature if the cause was not human-related; can each juvenile (especially in these large numbers) be adequately prepared to survive and thrive when released into the wild; and is there space in the environment for them, without causing harm to others already in the environment. This study concludes that the large numbers of animals currently being admitted to the centre may be reduced, through increased public education particularly to leave non-orphaned and uninjured juveniles in the wild. Furthermore, improvements in the centre's recording system may allow for use in funding requests and for various research opportunities.

Keywords: animal welfare, intake records, rehabilitation, South Africa, trends

Introduction

Worldwide there are thousands of wild animal rehabilitation centres; for instance, there are 5000 registered rehabilitators in the United States of America (USA) (Jacobs 1998), 650 - 800 in the United Kingdom (UK) (Kelly & Bland 2006; Leighton et al 2008), and 63 in South Africa (SA) (Chapter 2). Some are specialised, such as the 65 birds of prey centres in Spain (Fajardo et al 2000), and about 100 centres in 16 countries only dealing with marine mammals (Measures 2004). Rehabilitation centres provide treatment to injured, ill and orphaned wild animals, under temporary care, with the goal of releasing them back into their natural habitat once recovered or treated (Anon 2008). Rehabilitation centres are often privately funded (Kunz 1995; Jacobs 1998).

Analyses of the intake records at these rehabilitation centres may sometimes provide valuable insights into the threats to wildlife (Fix & Barrows 1990; Hartup 1996; Aitken 2004). For instance, birds and mammals seem to be more vulnerable as juveniles, being orphaned or abandoned (Dubois 2003), while reptiles and amphibians are mainly brought in because of vehicle collisions (Hartup 1996). Furthermore, intake records provide insight into the variety of species and the number of individuals that are vulnerable in the local area or region (Harden et al 2006), and whether this trend is seasonally related (Hartup 1996; Kelly & Bland 2006) or as a result of other factors, such as human population growth (Neese et al 2008). Knowledge about such factors affecting wildlife would allow for preventative measures to be implemented (Harden et al 2006; Drake & Fraser 2008). Rehabilitation centres would benefit from analysing their own records; by determining whether the changes they made to their rehabilitation methods had an improvement on decreased intake rates (Hartup 1996) and increased release rates (Parsons & Underhill 2005, Kelly et al 2008).

The few published inventories of intake trends, across species and time, have been in rehabilitation centres in the developed countries of temperate zones (England: Molony et al 2007; U.S.A: Hartup 1996, Harden et al 2006, Neese et al 2008; Canada: Dubois 2003), while studies in Africa have been done in Uganda (Kampala: Azikuru & Angubo 2007), and in South Africa (Nama Karoo: Visagie 2008; Cape Town: Parsons & Underhill 2005). Kampala and Nama Karoo are both rural areas, and the rehabilitation centres only admit birds (Azikuru & Angubo 2007) and only raptors (Visagie 2008), respectively. The rehabilitation centre in Cape Town is in an urban context, but it only admits marine birds (Parsons & Underhill 2005). No comprehensive studies have been conducted in the developed African urban context. We, therefore, investigated animal intake trends over four years at one of the largest urban wildlife rehabilitation centres in South Africa. This centre has been in existence for at least 25 years, and is situated in a suburb of Durban in the KwaZulu-Natal Province, near urban parks, industrial areas and the sea. It receives animals predominantly from the Durban metropolis, but occasionally from further afield in South Africa. The only animals not rehabilitated are very large ones (eg white rhinoceroses (*Ceratotherium simum*), black rhinoceroses (*Diceros bicornis*), African savanna elephants (*Loxodonta africana*)), or those in need of specialised care (eg seals (families Otariidae and Phocidae), penguins (family Spheniscidae), bats (order Chiroptera)). We expected that there would be no difference in the general trends of intake rates, and causes for intake, for international centres within suburban and urban environments. We predicted greater species diversity in South Africa, than those reported in the northern hemisphere, as a result of being in a different biogeographical realm, with relatively high biodiversity.

Materials and methods

Wild animal intake records at the rehabilitation centre were collated for four years (January 2004 - December 2007). All the data from the records were analysed, as all the information recorded by the staff at the rehabilitation centre was seen to be potentially useful. For ease of analysis and interpretation, data were categorised into three sections, namely: identification of the animal and information about the rescuer; causes for the intake; and condition and immediate fate (eg at clinic, euthanased) of the animal.

The first section included the following information: date, species, number of individuals, their age and sex, information on the person or organisation uplifting the animal (the "rescuer"), and the type (eg given food, drink) and duration of initial treatment administered prior to release to the rehabilitation centre (ie < 1day, < 1week, < 1 month, > 1 month). Species data were further grouped. Each animal was placed into an animal class (ie bird, mammal, reptile). For each class, animals were placed into a category. Categories for mammals (Appendix 2) and reptiles (Appendix 3) were derived from orders or sub-orders, whereas bird categories (Appendix 1) were derived subjectively either from their regional habitat (eg water habitat) (Hockey et al

2005), or if a habitat generalist, were grouped according their niche, namely feeding (eg aerial insectivore, raptor), and activity patterns (eg diurnal/ nocturnal). This categorical difference was due to the higher number of bird orders and sub-orders compared with those of mammals and reptiles. A context driven category would therefore result in smaller groupings, as well as provide insight into the habitat where birds were most vulnerable. For each category, depending on the number of individuals, animals were referred to by their species name (eg hadeda ibis) or they were placed into their common name grouping (eg cinnamon dove is placed into "dove") (Appendix 1). Often the admittance staff at the centre would only record common names. Those common name groupings with few individuals were placed within a larger group (eg "Marine group"). Several sources were used to identify order, family, and species names for birds (Newman 2002; Hockey et al 2005), mammals (Skinner & Chimimba 2005), reptiles (Alexander & Marais 2007) and non-indigenous fauna (del Hoyo et al. 1992; Nowak 1999).

The second section dealt with information relating to the reason/s for the animal being brought to the rehabilitation centre (Table 1). When no cause was given by the rescuer, probable causes were inferred by examining the records that gave the condition of the individual as well as other notes (eg an identification ring on a bird that might indicate a "probable pet" (Table 1)).

The third section described the condition of the animal as determined by a brief examination undertaken by the admittance staff soon after arrival of the animal. Conditions were grouped into six categories (Table 1) to enable meaningful comparisons. Since only the immediate fate of the individual (eg dead on arrival, placed in clinic) was recorded by the staff at the centre, the data shown in this category do not show the actual numbers of animals that died, were released or euthanased each month or year at the centre.

For each section, there was a category for when no information was provided. Terms used to define the causes and conditions were largely taken from the inventory described by Dubois (2003).

Data analyses

Since most individuals were brought in singly (91%), in all subsequent analyses the number of cases and not the actual number of individuals was used. Proportions were used to compare the relative contributions made by each group in a category (eg proportion of juveniles contributing to an overall age class). However, where appropriate and depending on normality, significant difference was determined using an unpaired Students t-test, Analysis of Variance (ANOVA) or Kruskal-Wallis ANOVA, and a Scheffé post-hoc test when significant. All statistical analyses were performed using Statistica 7 (StatSoft Inc., Tulsa, OK, USA).

Results

Trends in number of individuals and age groups admitted

Over four years, a minimum of 10 802 intake cases representing 12 948 individuals were admitted to the Durban rehabilitation centre. The average number of individuals admitted each year was 2701 ± 94 (mean ± SE) and this did not differ significantly between years (ANOVA: $F_{(3,44)} = 0.28$, $p = 0.838$). Monthly average intake was 255 ± 14, with a significant difference between months (ANOVA: $F_{(11,36)} = 15.33$, $p < 0.001$) (Fig. 1). Over the four years, the highest monthly intake was consistently in November. Grouping the months into seasons showed a significant seasonal trend in intake rates (ANOVA: $F_{(3,44)}$= 25.26, $p < 0.001$). Intake of individuals was generally higher in both summer (December-February: 322 ± 19) and spring (September-November: 280 ± 24) compared with both autumn (March-May: 167 ± 18), and winter (June-August: 131 ± 8) (Scheffé post-hoc: $p < 0.001$). No difference in intake rate between spring and summer (Scheffé post-hoc: $p = 0.441$), or winter and autumn (Scheffé post-hoc: $p = 0.572$), were observed.

Seasonal changes in numbers of individuals were also observed within each age group (Fig. 1), namely adults (ANOVA: $F_{(3,12)}$= 5.67, $p = 0.012$), sub-adults (ANOVA: $F_{(3,12)}$= 6.92, $p = 0.006$), juveniles (ANOVA: $F_{(3,12)}$= 15.50, $p < 0.001$) and infants (ANOVA: $F_{(3,12)}$= 20.45, $p < 0.001$). The groups with unknown ages or with multiple ages were excluded from this analysis. Adult numbers were significantly higher in spring compared with autumn (Scheffé post hoc: $p = 0.038$); while sub-adult numbers were significantly higher in summer compared with winter (Scheffé post hoc: $p = 0.014$). Both juveniles and infants showed a more pronounced seasonal difference in numbers. Juvenile numbers were significantly larger in summer compared with both autumn (Scheffé post hoc: $p = 0.004$) and winter (Scheffé post hoc: $p < 0.001$), as well as being significantly greater in spring compared with winter (Scheffé post hoc: $p = 0.007$); while infant numbers were also significantly larger in summer compared with both autumn (Scheffé post hoc: $p = 0.007$) and winter (Scheffé post hoc: $p = 0.002$), and significantly larger in spring compared with both autumn (Scheffé post hoc: $p = 0.001$) and winter (Scheffé post hoc: $p < 0.001$). In total, over four years, juveniles contributed the most to all animal intake to the centre (46%, n = 4640 in total; 1160 ± 105 per annum), followed by adults (20%, n = 2048 in total; 512 ± 38 per annum), sub-adults (18%, n = 1817 in total; 454 ± 29 per annum) and infants (15%, n = 1506 in total; 377 ± 43 per annum). This trend was similar in each animal class, with juveniles contributing 48% (n = 4338), 30% (n = 229) and 36% (n = 64) of four years of bird, mammal and reptile intakes respectively.

Trends in animal class and species

Most of the intake at the rehabilitation centre were birds (90%, n = 9700 in total; 2425 ± 72 per annum), followed by mammals (8%, n = 823, 206 ± 23) and reptiles (2%, n = 228, 57 ± 9). A total of 51 (13 ± 5) intake records did not state what kind of animal it was. In total, there were 208 species, including 151 bird species from 20 orders and 69 families (Appendix 1); 41 mammal species from 11 orders and 23 families (Appendix 2); and 16 reptile species from 3 orders 9 families (Appendix 3).

The most common bird category were those that occurred commensally with humans in urban or suburban areas, hereafter referred to as “urban habitat” (82%, n= 7915 in total, 1979 ± 53 per annum), while the other categories contributed less than 5% each (Fig. 2), including an “other” category, with 2 chickens (order Galliformes, *Gallus gallus*) and 1 cockatiel (order Psittaciformes, *Nymphicus hollandicus*) (refer to Appendix 1 for the species listed in each category). The most common bird species were those that occurred in the urban habitat, especially doves (order Columbiformes, 27%, n = 2653 in total), hadeda ibis (order Ciconiiformes, *Bostrychia hagedash*, 10%, n = 967 in total), and pigeons (order Columbiformes, 9%, n = 861 in total) (Fig. 2).

Those mammals belonging to order Primates were the most prevalent of mammalian categories (47%, n = 384 in total, 96 ± 17 per annum). This was followed by order Carnivora (14%, n = 117, 29 ± 3), and order Ruminantia (16%, n = 133, 33 ± 4), while the other categories contributed less than 5% each (Fig. 3). The two most common mammal species were vervet monkeys (order Primates, *Cercopithecus* *aethiops*, 44%, n = 365 in total) and blue duiker (order Ruminantia, *Philantomba monticola*, 10%, n = 84 in total) (Fig. 3).

The most common reptile category was order Chelonia (80%, n = 182 in total, 46 ± 7 per annum), followed by order Squamata, sub-order Sauria (12%, n = 28; 7 ± 2), order Squamata, sub-order Serpentes (7%, n = 17; 4 ± 2), and order Crocodylia (<1%, n = 1). The two most common reptile species was the leopard tortoise (order Chelonia, *Stigmochelys pardalis*, 34%, n = 78 in total, 20 ± 3 per annum), and hinged tortoise (order Chelonia, *Kinixys* sp., 16%, n = 36 in total, 9 ± 2 per annum).

Rescuer and whether animals were treated before intake at the rehabilitation centre

Most animals were brought to the rehabilitation centre by private individuals (66%, n = 7148 in total, 1787 ± 53 per annum) and a nearby bird park (21%, n = 2289, 572 ± 25), while others were brought in by a group consisting of other rehabilitators and the local nature conservation authority (4%, n = 427, 107 ± 19), left in the after hours box at the centre (3%, n = 326, 82 ± 20), brought in by an animal welfare organisation (SPCA) (3%, n = 290, 73 ± 10) or rescued by the rehabilitation centre itself (2%, n = 4173, 3 ± 22). A total of 149 records (1%, 37 ± 8) did not state who admitted the animal to the rehabilitation centre.

Excluding those records without data on whether or not animals had been treated prior to admittance (40%, n = 4304 in total, 1076 ± 33 per annum), there was no significant difference (t-test: t= 0.71, df = 6, p = 0.505) in whether the animal had been treated (31%, n = 3314, 829 ± 30), or not (29%, n = 3184, 796 ± 35). Most treated the animal only for one day (81%, n = 2689, 672 ± 16), while there were relatively equal numbers of those treated for less than 1 week (10%, n = 340, 85 ± 26), treated for less than 1 month (4%, n = 145, 36 ± 6) and those treated for more than 1 month (4%, n = 140, 35 ± 6). The animals that were treated for 2 - 29 days prior to placement at the rehabilitation centre were generally without injuries (45%, n = 220), but 28% (n = 137) were injured. A number of animals of those who had been treated had to be euthanased due to their injuries (15%, n = 73 in total), suggesting that a delay in bringing an animal to the centre may have either lead to injuries being caused by and/or compounded by the care they received from the person who found them.

Causes

An explanation of the respective terms that were used to describe the causes for rescue are shown in Table 1. Besides the large number of "unknown" cases (31%), the four main causes for birds being brought to the rehabilitation centre were probable young (when cause was inferred, 20%), young (17%), dog (*Canis familiaris*)/cat (*Felis catus*) attack (13%) and "wrong place- other" (4%, eg found in car) (Table 2). Similarly, for each bird category, the highest proportion was usually listed as "unknown" (29 - 39%). If this cause was excluded, the most common cause was "young", except for marine birds, which were mainly found entangled, and raptors, which were mainly involved in vehicle collisions (Table 2). For mammals, besides the large number with an unknown history (18%), the main causes were dog/cat attack (13%), wrong place (12%), vehicle impact (12%) and young (11%) (Table 2). Similarly, for each mammal category the main cause was generally dog/cat attack (Table 2). Reptiles were mostly admitted to the rehabilitation centre because they were found in the wrong place, which included the sub-categories "other" (20%), on road (16%) and "probable" (when cause was inferred, 14%); or because they were ex-pets ("probable": 11%, known: 10%) (Table 2). Most ex-pets were leopard tortoises

(70%, n = 16). For each reptile category, the main cause for admission was being found in the wrong place (Table 2).

Condition and immediate fate

Most of the birds and mammals with an unknown history for cause of admission were injured (59%, n = 1759 in total; 59%, n = 86 in total, respectively), while those that were young were mostly uninjured (71%, n = 1158, 56%, n = 49 respectively). In general, birds and reptiles admitted did not have any visible injuries (44%, n = 4246 in total, 1062 ± 107 per annum; 63%, n = 144 in total, respectively), while mammals were mostly injured (48%, n = 393 in total). Although it was not a common condition, there were 236 animals that were diseased, namely birds (2% of all animal types, n = 217, 54 ± 7 per annum), especially pigeons and doves; and mammals (2% of all animal types, n = 19), especially banded mongoose and vervet monkey. Most of the diseased animals were immediately euthanased (66%, n = 155).

Over the four years, out of all animal classes, most individuals brought to the centre were placed into the clinic (70%, n = 7546). Some (18%, n = 1911) were immediately euthanased, while others (7%, n = 759) had unknown placements and almost equal proportions (1 - 2%) were dead on arrival (n = 107), died soon after arrival (n = 231), were released (n = 147), given to another rehabilitator for care (n = 43) or were in a group where individuals had different fates recorded (n = 24).

Discussion

The large numbers and regularity of animal intake at this rehabilitation centre between years allowed for consistent trends to emerge. The annual average intake of 2701 animals was similar to that recorded at a centre in Canada (over 2000 animals: Dubois

& Fraser 2003). Diversity of bird species was similar (151 over four years) to that found in one study in USA (199 over 15 years; Harden et al 2006), but higher than in Uganda (32 over four years; Azikuru & Angubo 2007). Furthermore, the variety of reptiles (16 species, one centre, four years) was greater than that documented in Canada (six species, 11 centres, 12 years) (Dubois & Fraser 2003) but lower than another study in the USA (20 species, one centre, 14 years) (Hartup 1996). The relatively high species diversity in the South African rehabilitation centre may be the result of the higher diversity of the Afrotropical region compared with countries in the Nearctic (USA, Canada) regions (Newton 2003). The low species diversity of animals admitted for rehabilitation in Uganda is maybe due to socio-economic and cultural differences, rural people perhaps being less likely to bring wild animals to rehabilitation centres (Kellert 1991 in Measures 2004).

A trend seen throughout the world is that the common species living in close association with humans are the most frequently admitted to rehabilitation centres (Deem et al 1998), because of the increased probability of injury and also of subsequent detection (Reeve & Huijser 1990; du Toit 1999; Barnett & Westcott 2001). Sometimes these species have grown in numbers and spread into previously unoccupied areas, because they are able to successfully adapt to man-made changes in the environment (Hockey et al 2005). They are also often tolerant of humans (Hockey et al 2005; Drake & Fraser 2008). The three most common bird species admitted to the rehabilitation centre in this study have all benefited from increased roost and nesting sites, when trees were planted in previously open areas (hadeda ibis: Macdonald et al 1986; doves: Rowan 1983) or suitable man-made structures (eg roofs) exist (pigeons: Rowan 1983). They have also benefited from increased foraging sites, for instance where cities and agricultural farming provide food for pigeons and doves (Rowan 1983). The increased number of artificial water bodies and areas under irrigation (eg suburban gardens) also benefit birds, such as the hadeda ibis (Macdonald et al 1986). Meanwhile the vervet monkey, the mammal most commonly admitted to the rehabilitation centre, is common in KwaZulu-Natal suburbia (Skinner & Chimimba 2005), largely due to an overlap in suitable habitat and/or increased foraging opportunities in suburban houses and gardens (Henzi 1979), as well as a decrease in natural predators (Whittsit 1995). Leopard tortoises are the most common reptile admitted, probably due to it being the most widely distributed tortoise in South Africa and a common choice of reptilian pet (Boycott & Bourquin 2000). Commonly admitted species listed in other studies, such as mallard ducks in Canada (Dubois & Fraser 2003; Drake & Fraser 2008) and hedgehogs in the UK (Kirkwood & Best 1998), are likely also as a result of successfully adapting to man-made changes to environment.

Wildlife rehabilitation centres are generally established to deal with casualties or consequences from man-made hazards or developments (Trendler 1995a; MWAC 2009). Common causes of admittance of birds and mammals in Canada include orphaned or abandoned young (25%, 66% respectively), cat attack (23%, 13% respectively) and vehicle impact (9% and 8% respectively) (Dubois 2003). A similar analysis in the UK revealed a similar trend, where 25% of all animals admitted were abandoned young, while 8% were due to cat attack (Kirkwood & Best 1998). The main causes in this study were similar, but varied between animal classes. The main cause of admittance in birds was being found young, for mammals it was dog or cat attack, and for reptiles, being found in a ‘wrong’ place. This is likely a result of birds being able to live and breed in close proximity to humans, and thus their juveniles are readily found and easily picked up, while mammals generally avoid humans and so are only encountered when in conflict with humans. Reptiles, especially snakes, are generally regarded with fear (Marais 2004), and thus commonly found where they are not wanted. Causes also varied for different taxa, perhaps related to foraging methods (Kelly & Bland 2006), where raptors are especially vulnerable to collisions (Deem et al 1998; Kelly & Bland 2006; Visagie 2008; this study), or due to their habitat, where marine birds are vulnerable to oil spills (Carter 2003; Barham et al 2006), and entanglement by fishing lines (Trendler 1995a; Jacobs 1998; this study).

Including all animal classes, juveniles contributed the most to the total animal intake at the Durban rehabilitation centre. In addition, the seasonal increase in the number of animals was directly linked to an increase in number of juveniles in spring and summer, similarly documented in hedgehogs (Reeve & Huijser 1999) and in seals (Barnett & Westcott 2001). In the present study, this was a time when there was an overlap between bird and mammal species in their peak-breeding season in southern Africa (Hockey et al 2005; Skinner & Chimimba 2005). These juveniles were assumed to have been abandoned or orphaned (Jacobs 1998, Beringer et al 2004), and thus were taken to the centre for hand-raising. Even though there are instances when juveniles probably need help (eg orphaned bears: Clark et al 2002; and abandoned ducklings: Drake & Fraser 2008), various authors have documented that they are sometimes picked up unnecessarily (eg deer fawns: Beringer et al 2004, von Klemperer 2008; seal pups: Measures 2004; and owl chicks: Leighton et al 2008), as they are not really abandoned or orphaned. Not only does this have ethical consequences, but when examining the natural mortality for infant and juvenile doves (the most commonly admitted bird group), nesting success (survival until fledging) has been estimated to be only 40% for redeyed doves (*Streptopelia semitorquata*), 38% for Cape turtle doves (*S. capicola*) and 46% for laughing doves (*S. senegalensis*);

largely due to predation, desertion and bad weather (Rowan 1983). This raises two important issues with rehabilitating juveniles: should humans be interfering with nature if the cause was not human-related (see Kirkwood 1992), and if the environment is at carrying capacity, is it able to support more individuals (Caldecott & Kavanagh 1983). The third issue with rehabilitating juveniles is whether juveniles can be adequately prepared to survive and thrive when released into the wild (Bennett 1992; Csermely 2000). In the rehabilitation process there is the likelihood of juveniles becoming human-imprinted, habituated or tame (Aitken 2004; Sleeman 2007), with human-imprinted individuals especially being likely to become aggressive or a nuisance by approaching humans for food and/or companionship (Alt & Beecham 1984; Beringer et al 1994). Similarly, hand-raising songbirds without conspecifics and/or in close association with heterospecifics, has shown to negatively influence their song development, and thus on their ability to find a mate or defend a territory (Spencer et al 2007). Therefore, the public must be advised to leave non-orphaned and uninjured juveniles in the wild (Trendler 1995a; Jacobs 1998).

Besides identifying the threats to wildlife (Fix & Barrows 1990; Reeve & Huijser 1999), analysis of intake records could be useful to conservation. For instance, specific areas where animals frequently encounter harm may be identified from intake records (Curtis & Jenkins 2002; Harden et al 2006; Drake & Fraser 2008). This information may then be used to place preventative measures at these sites (Drake & Fraser 2008), such as tunnels and culverts to help with tortoise road crossings (Guyot & Clobert 1997). Intake records may also be used to monitor diseases affecting wild animals (Kirkwood 1992; Measures 2004; Harden et al 2006), such as sarcoptic mange, canine distemper and rabies in foxes (Kelly & Sleeman 2003). Additional uses include monitoring population trends in an area, to pick up an expansion of a native range or if a decrease is noticed, it could be an early warning signal of an environmental change (Harden et al 2006; Neese et al 2008). Generally these have been under-utilised and so may have resulted in poor completion of intake records at this centre, and elsewhere; as those completing them did not realise its importance (Italy: Fajardo et al 2000, Canada: Dubois & Fraser 2003, USA: Kelly & Sleeman 2003, Harden et al 2006).

Additionally, intake records should be analysed by the rehabilitation centres themselves to learn from their successes and failures (Trendler 1995b). One centre noticed that release rates of African penguins (*Spheniscus demersus*), had improved over years as a result of refinements of their rehabilitation techniques (Parsons & Underhill 2005). In addition, an accurate record of where an animal was found enables it to be released back into the appropriate habitat (Harden et al 2006). Furthermore, studies have shown that intake records can be used to identify individuals that are high-risk, so that special care is provided to these individuals (eg ducklings with low body mass, Drake & Fraser 2008) or provided to those with less severe injuries (Molony et al 2007). The opportunities for research are numerous if all rehabilitators input their intake records into a centralised online database, such as one set up by the British Wildlife Rehabilitation Council (Anon 2009). Furthermore, an automated recording system could help rehabilitation centres generate accurate trends for use in funding requests or in permit applications.

Animal welfare implications

The consistently large numbers of juveniles admitted in the current study reflects a need for greater public education at this centre to prevent these numbers in the future (Hartup 1996; Dubois & Fraser 2003). Otherwise, the large numbers of juveniles limit the practicality of being able to provide adequate care to each individual and prepare them for release, and increase the possible negative impact of releasing these individuals on the environment. We suggest that intake records should be better utilised by rehabilitation centres as well as conservation authorities, where analyses could reveal for example: the threats to wildlife and the specific areas where animals frequently encounter harm, so that preventative measures could be put in place at these sites; and they could reveal improvements in rehabilitation techniques.

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Table 1. List and descriptions of causes and conditions affecting animals admitted to the rehabilitation centre. Note that “probable” indicates these causes were inferred.

	Factors	Description
Cause	Unknown	Nothing was written in the records
	Young	Orphaned, abandoned, fell from nest, fledgling
	Probable young	Infant or juvenile with no visible injuries, excl. reptiles
	Hand-raised	Hand-raised animal >1 week but < 1 month
	Ex-pet	Pet handed in by owners
	Probable ex-pet	Pet not handed in by owners (ie was released/escaped) eg exotic tortoise, bird has identification ring
	Removed animal	Included if the animal was found tied up, being sold; confiscated by nature conservation
	Dog/cat attack	Attack by dog (*Canis familiaris*) or cat (*Felis catus*)
	Other animal attack	Includes attack by non-domestic animal eg vervet monkey
	Human attack	Includes intentional (eg hit with sticks/bricks, shot, beaten, poisoned, in snare) and accidental (eg driven over by lawn mower)
	Vehicle impact	Hit or driven over by car, tractor, plane, train
	Probable vehicle impact	Found in road + injured and/or concussed (excl. infant/juvenile birds)
	Other impact	Flew into window, wall or door
	Probable other impact	If concussed (excl. infant/juvenile birds), or if bird was released immediately after admission
	Adhesive	Covered in adhesive, including glue, tar, oil
	Entangled	Entangled in string, plastic, hair, barbed wire, fishing line
	Wrong place-water bodies	Found in the pool, dam, other water bodies
	Wrong place-other	Found in car, building, garden, roof; stuck in hedge; nest intentionally removed
	Wrong place-road	Found in the road, parking lot, railway line
	Probable wrong place (water bodies, other, road)	Animals with NVI or if released immediately. Includes reptiles, adult/sub-adult mammals, groups of adult/sub-adult with juveniles/infant birds)
	Other	If electrocuted, burnt in fire
Condition	Unknown	No condition recorded
	No visible injuries (NVI)	No visible injuries, includes if weak, dehydrated, exhausted, lethargic and in poor condition
	Possibly diseased/ injured	Includes if the animal is thin, full of fly eggs, has fever, diarrhoea, vomiting, and if not standing/ walking/ flying properly (but NVI)
	Diseased	Includes avian pox, trichomoniasis, salmonellosis, chlamydiosis, rabies, distemper, mange, tetanus (even if also injured/concussed).
	Injured	Injuries include wounds, broken bones, paralysed, blind, and concussed (includes if disorientated, neurological symptoms)
	Dying/DOA	Individuals dying and dead on arrival

Table 2. Main causes (%, total n, mean ± SE) resulting in animals admitted to the rehabilitation centre for each category within bird, mammal and reptile classes (Refer to Appendices for description of categories, and refer to Table 1 for description of causes and conditions).

Class	Category	Cause	%	Total	Mean ± SE
Bird	All	Unknown	31	2964	741 ± 17
		Probable young	20	1977	494 ± 58
		Young	17	1607	402 ± 21
		Dog/cat attack	13	1221	305 ± 23
		Wrong place-other	4	351	88 ± 20
	Marine	Entangled	12	17	4 ± 1
	Water	Probable young	26	109	27 ± 4
	Raptors	Vehicle impact	17	16	4 ± 1
	Grassland	Probable young	15	17	4 ± 2
	Nocturnal	Probable young	12	18	5 ± 1
	Aerial insectivores	Probable young	24	79	20 ± 5
	Specialist	Dog/cat attack	15	79	20 ± 2
	Urban habitat	Probable young	21	1691	423 ± 45
	Other	Wrong place-other	67	2	-
Mammal	All	Unknown	18	147	-
		Dog/cat attack	13	110	-
		Wrong place-other	12	98	-
		Vehicle impact	12	97	-
		Young	11	87	-
	Primates	Vehicle impact	20	76	-
	Carnivora	Young	20	23	-
	Ruminata	Wrong place-other	29	38	-
	Chiroptera	Dog/cat attack (Besides unknown)	28	16	-
	Hyracoidea	Dog/cat attack	30	7	-
	Rodentia	Probable young	42	5	-
	Afrocoricida	Dog/cat attack	43	6	-
	Lagomorpha	Dog/cat attack	28	8	-
	Eulipotyphla	Dog/cat attack	75	6	-
	Suiformes	Various (eg young)	20	1	-
	Exotics	Removed animal	25	2	-
Reptile	All	Wrong place-other	20	45	-
		Wrong place-road	16	36	-
		Probable wrong place	14	32	-
		Probable ex-pet	11	24	-
		Ex-pet	10	23	-
	Chelonia	Wrong place-other	20	37	-
	Crocodylia	Man-made attack	100	1	-
	Squamata: Sauria	Wrong place-other	14	4	-
	Squamata:	Wrong place-other	24	4	-
	Serpentes	Dog/cat attack	24	4	-

Figure legends

Figure 1 Mean (± SE) number of individuals of different age classes admitted each month (bars) to an urban SA rehabilitation centre and monthly mean for all ages combined over four years (2004-2007). Note that the monthly mean ("total") follows the second y-axis.

Figure 2 Mean (±SE) number of each group within eight different bird categories (excluding "other" category) admitted each year to an urban SA rehabilitation centre. (See Appendix 1 for a list of species abbreviations and family names).

Figure 3 Mean (±SE) number of each group within 11 different mammal orders and one group of exotics admitted each year to an urban SA rehabilitation centre. (See Appendix 1 for a list of species abbreviations and family names).

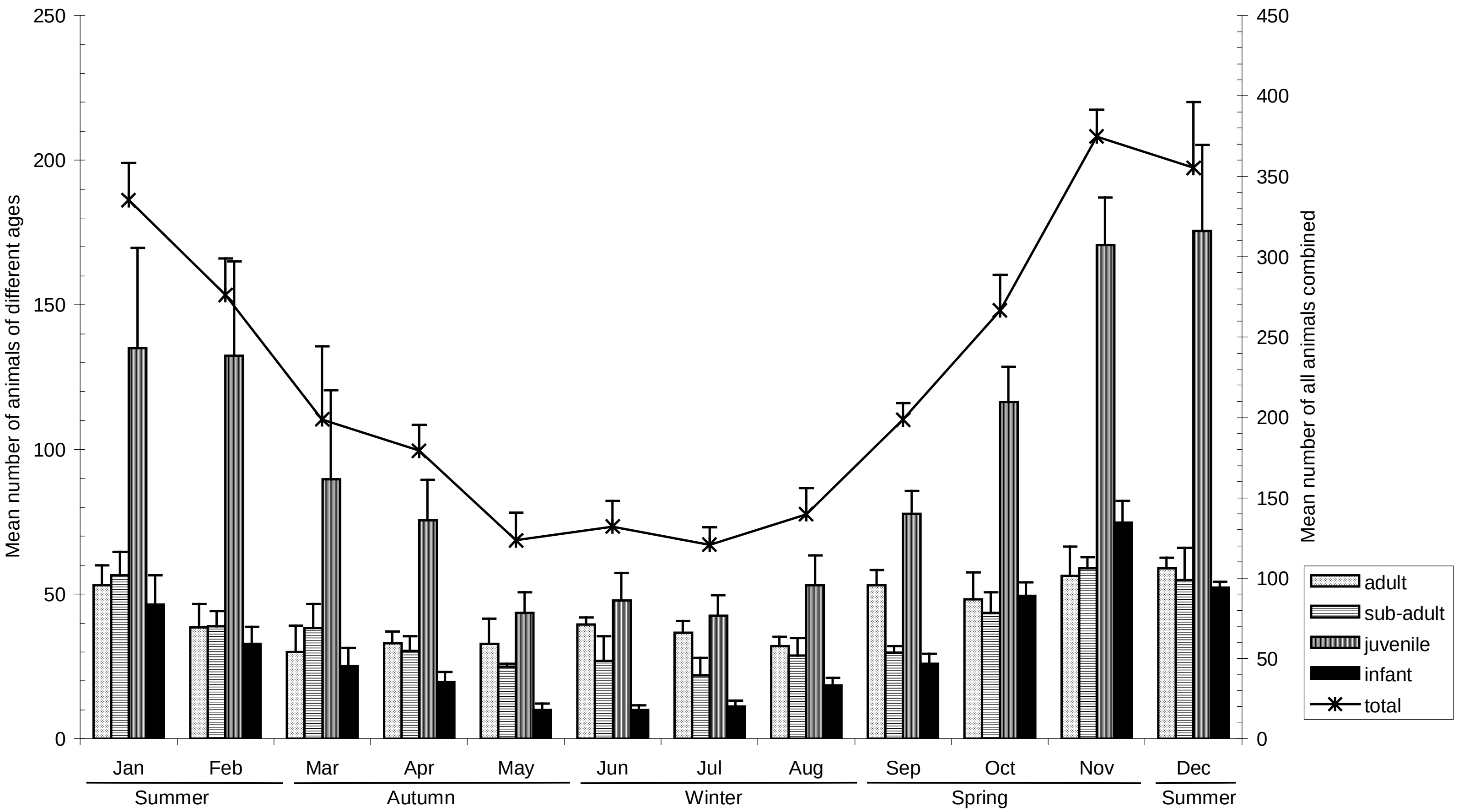

Figure 1 Mean (± SE) number of individuals of different age classes admitted each month (bars) to an urban SA rehabilitation centre and monthly mean for all ages combined over four years (2004-2007). Note that the monthly mean ("total") follows the second y-axis.

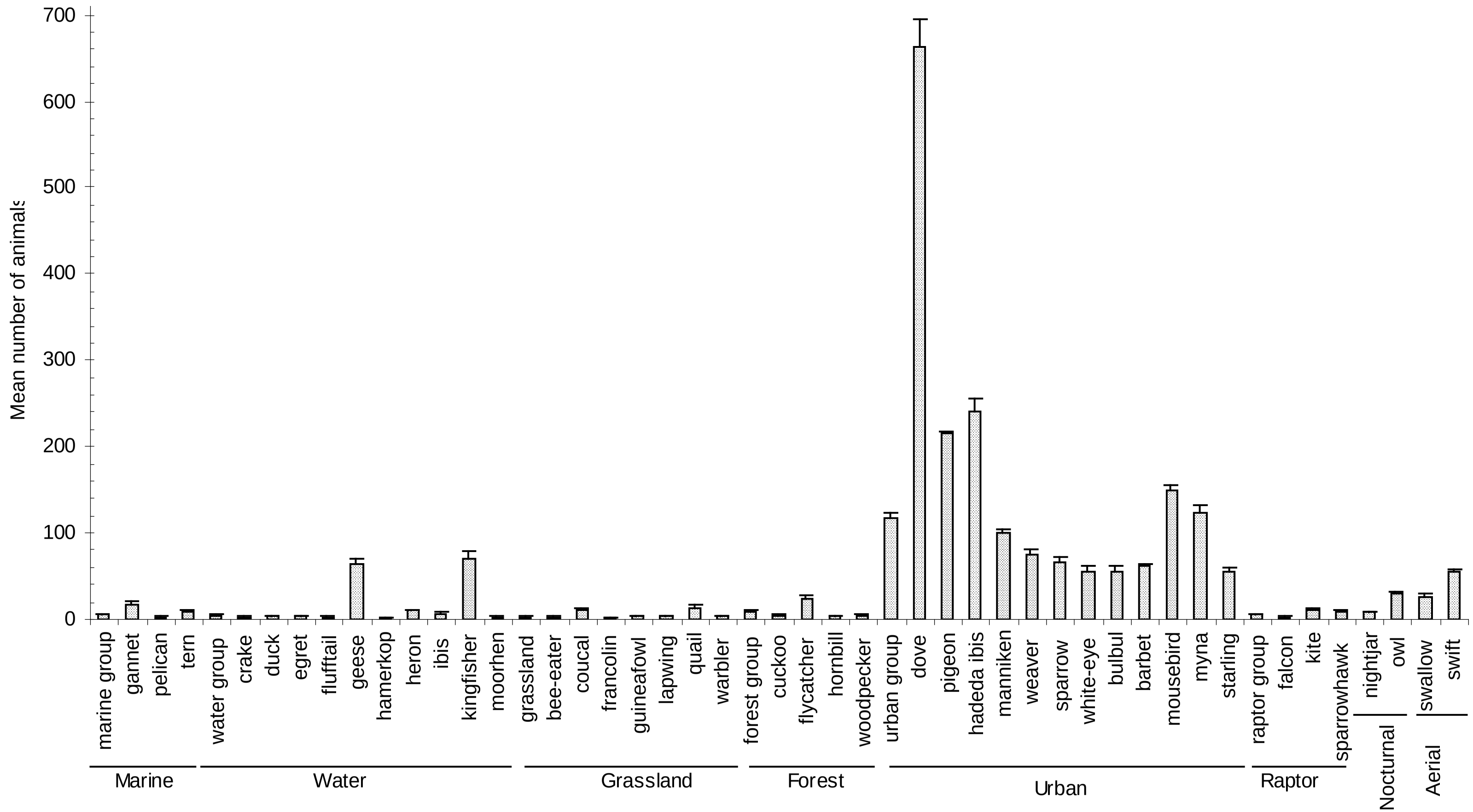

Figure 2 Mean (±SE) number of each group within eight different bird categories (excluding “other” category) admitted each year to an urban SA rehabilitation centre. (See Appendix 1 for a list of species abbreviations and family names).

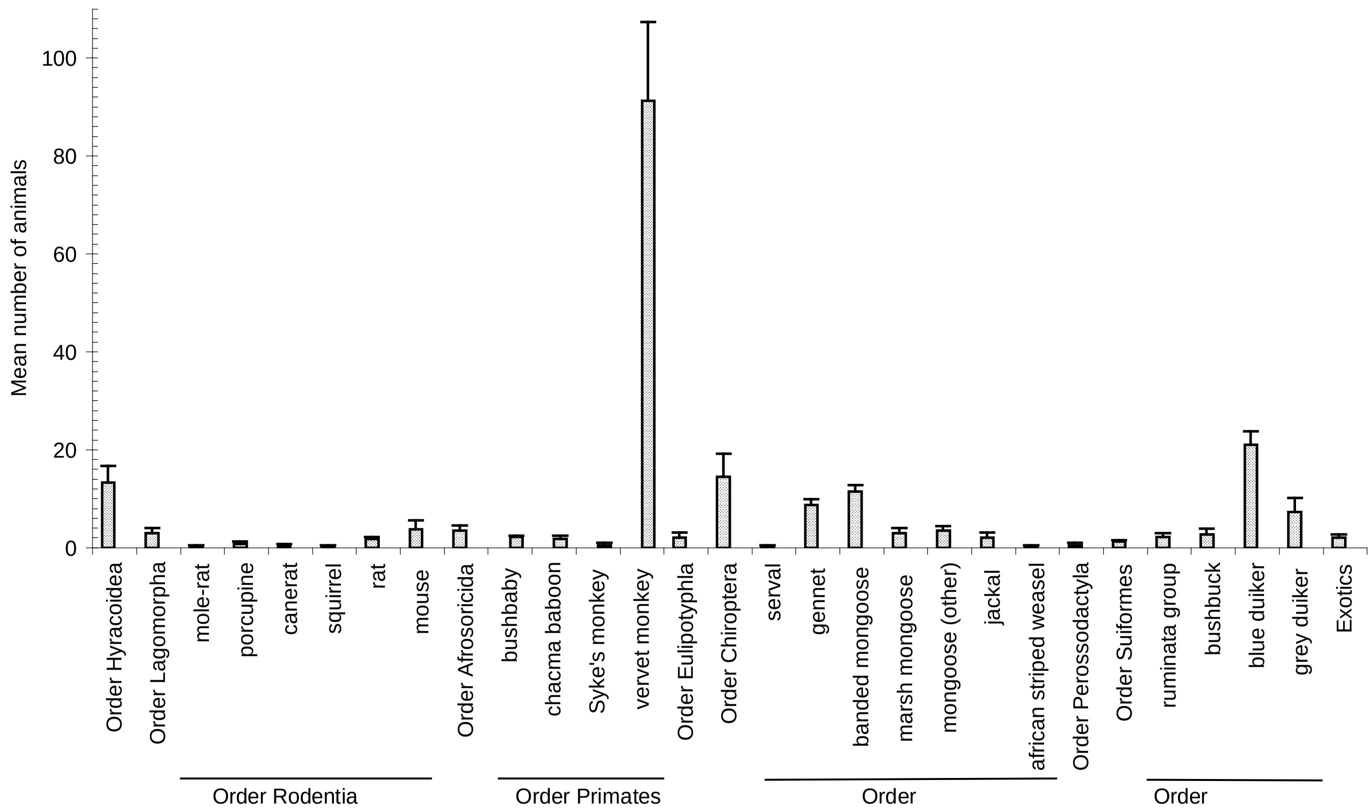

Figure 3 Mean (±SE) number of each group within 11 different mammal orders and one group of exotics admitted each year to an urban rehabilitation centre. (See appendix 1 for a list of species abbreviations and family names).

Appendix 1. List of species (if recorded by admittance staff) admitted to centre and their common and family names within each bird category (developed using habitat rather than taxonomic associations, to allow for more meaningful smaller groupings).

Bird category	Group	Group name (family name): species name
Marine habitat	Marine group	Cormorant (Phalacrocoracidae); Penguin (Spheniscidae): African; Petrel (Procellariidae); Shearwater (Procellariidae): Wedge-tailed; Skua (Laridae): Subantartic
	Gannet	Sulidae: Cape
	Gull	Laridae
	Pelican	Pelecanidae
	Tern	Laridae: Little
Water habitat	Water group	Crane (Gruidae): Grey crowned; Grebe (Podicipedidae): Little; Thick-knee (Burhinidae): Spotted; Painted-snipe (Rostratulidae): Greater; Sandpiper (Scolopacidae); Spoonbill (Threskiornithidae): African; Stork (Ciconiidae): Woolly-necked
	Crake	Rallidae: African, Black, Corn
	Duck	Anatidae: White-faced, Fulvous, Muscovy (exotic), Yellow-billed
	Egret	Ardeidae
	Flufftail	Rallidae: Buff-spotted
	Goose	Anatidae: Egyptian, Spur-winged, Domestic
	Hamerkop	Scopidae
	Heron	Ardeidae: Grey, Grey-backed, Goliath, Black-headed
	Ibis	Threskiornithidae: African sacred, Southern bald
	Moorhen	Rallidae
	Kingfisher	Alcedinidae: Malachite, African pygmy-kingfisher Dacelonidae: Brown-hooded, Mangrove Cerylidae: Giant, Pied
Grassland habitat	Grassland group	Bustard (Otididae): Black-bellied; Buttonquail (Turnicidae); Cisticola (Cisticolidae); Sparrowlark (Alaudidae); Lark (Alaudidae); Partridge (Phasianidae); Pheasant (Phasianidae: exotic)
	Bee-eater	Meropidae
	Francolin	Phasianidae: Crested Francolin, Natal Spurfowl
	Coucal	Centropodidae: Burchal's
	Guineafowl	Numididae: Helmeted
	Lapwing	Charadriidae: Black-smith
	Quail	Phasianidae: Harlequin
	Warbler	Slyviidae
Forest habitat	Forest group	Babbler (Sylviidae); Chat (Muscicapidae); Honeyguide (Indicatoridae); Hoopoe (Upupidae) African; Roller (Coraciidae): European; Tchagra (Malaconotidae); Tit (Paridae); Trogon (Trogonidae): Narina; Twinspot (Estrildidae)
	Cuckoo	Cuculidae: Diederik, African emerald
	Flycatcher	Muscicapidae: Southern black, African dusky Monarchidae: African paradise-flycatcher
	Hornbill	Bucerotidae: Trumpeter Bucorvidae: Southern ground-hornbill
	Woodpecker	Picidae

Appendix 1.cont.

Bird category	Group	Group name (family name): species name
Urban habitat (incl. Suburban gardens)	Urban group	Raven (Corvidae): White-necked; Crow (Corvidae): House, Pied; Drongo (Dicrurida): Fork-tailed; Waxbill (Estrildidae): Common; Firefinch (Estrildidae); Canary (Fringillidae): Cape, Yellow-fronted; Shrike (Laniidae): Common fiscal; Puff-back (Malaconotidae):Black-backed; Wagtail (Motacillidae); Turaco (Musophagidae): Purple-crested, Grey go-away bird; Sunbird (Nectariniidae): Collared; Oriole (Orolidae); Bishop (Ploceidae): Southern red; Thrush (Muscicapidae): Olive, Spotted-ground; Robin (Muscicapidae):White-starred; Robin-chat (Muscicapidae): Cape, Red-capped; Whydah (Viduidae): Pin-tailed
	Dove	Columbidae: Cape turtle-dove; Laughing, Red-eyed, Tambourine doves; Emerald-spotted wood-dove
	Pigeon	Columbidae: Rock dove; Speckled pigeon; African green-pigeon; African olive-pigeon
	Hadeda ibis	Threskiornithidae
	Mannikin	Estrildidae: Bronze
	Weaver	Ploceidae: Masked-weaver (lesser/southern); Spectacled, Thick-billed weavers
	Sparrow	Passeridae: House, Southern grey-headed
	White-eye	Zosteropidae: Cape
	Bulbul	Pycnonotidae: Dark-capped
	Barbet	Lybiidae: Black-collared, Crested, White-eared barbets; Tinkerbird
	Mousebird	Collidae: Speckled
	Myna	Sturnidae: Common
	Starling	Sturnidae: Cape glossy, Violet-backed, Red-winged
Raptors	Raptor group	Accipitridae: Buzzard: Jackal, Steppe; Eagle: African crowned, Long-crested, Martial, Wahlberg's; Snake-eagle; African harrier-hawk; Vulture; Unknown sp.
	Falcon	Falconidae: Lanner, Peregrine
	Kite	Accipitridae: Black-shouldered, Black
	Sparrowhawk	Accipitridae: Black
Nocturnal	Nightjar	Caprimulgidae
	Owl	Tytonidae: Barn Strigidae: Marsh owl; Cape, Spotted, and Verreaux's eagle-owls; Southern white-faced scops-owl; African wood-owl
Aerial insectivores	Swallows	Hirundinidae: Barn, Striped (lesser/greater)
	Swifts	Apodidae: Common, White-rumped
Other	Chicken	Phasianidae: *Gallus gallus*
	Cockatiel	Pstittacidae: *Nymphicus hollandicus*

Appendix 2. List of species (if recorded by admittance staff) admitted to centre and their common and family names within each mammal category (developed according to taxonomic grouping and whether exotic to SA and/or KZN province).

Mammal category	Group	Family name: species name
Order Hyracoidea	Hyrax	Procaviidae: rock, tree hyrax
Order Lagomorpha	Scrub hare	Leporidae
Order Rodentia	Mole-rat	Bathyergidae
	Porcupine	Hystricidae
	Canerat	Thryonomyidae
	Squirrel	Sciuridae
	Rat	Muridae
	Mouse	Muridae
Order Afrosoricida	Golden mole	Chrysochloridae
Order Primates	Galago	Galagidae: Greater, South African
	Chacma baboon	Cercopithecidae
	Syke's monkey	Cercopithecidae
	Vervet monkey	Cercopithecidae
	Monkey (unknown)	Unknown
Order Eulipotyphla	Shrew	Soricidae
Order Chiroptera	Bat	Pteropodidae (fruit-eating); Molossidae (Free-tailed), Vespertilionidae (vesper)
Order Carnivora	Serval	Felidae
	Gennet	Verridae: Spotted
	Banded mongoose	Herpestidae
	Marsh mongoose	Herpestidae
	Mongoose (other)	Herpestidae: Large grey, slender, yellow
	Jackal	Canidae: Black-backed
	African striped weasel	Mustelidae
Order Perossodactyla	Plains zebra	Equidae
Order Suiformes	Bushpig	Suidae
	Common warthog	Suidae
Order Ruminata (family Bovidea)	Bushbuck	Sub-family Bovinae
	Blue duiker	Sub-family Antilopinae
	Grey/common duiker	Sub-family Antilopinae
	Ruminata group	Sub-family Antilopinae: unknown duiker, red duiker, reedbuck, oribi, impala
Exotic	Suricate/meerkat	Order Carnivora, Family Herpestidae: *Suricata suricatta*
	European rabbit	Order Lagomorpha, Family Leporidae: *Oryctolagus cuniculus*
	Marmoset	Order Primates, Family Callitrichidae: various sp.

Appendix 3. List of species (if recorded by admittance staff) admitted to centre and their common and family names within each reptile category (developed according to taxonomic grouping)

Reptile category	Common name	Family name: species name
Order Squamata: Sub-order Serpentes	Snake (common)	Colubridae: House, Spotted bush, Eastern Green snake, Herold
	Black mamba	Elapidae
	Night Adder	Viperidae
	Snake (exotic)	Colubridae: Corn snake (*Elaphe guttata*)
Order Squamata: Sub-order Sauria	Southern tree agama	Agamidae
	Chameleon	Chamaeleonidae
	Water monitor	Varanidae
Order Crocodylia	Nile Crocodile	Crocodylidae
Order Chelonia	Terrapin	Pelomedusidae
	Tortoise	Testudinidae: exotic to KwaZulu-Natal Province (Angulate tortoise, Parrot-beaked padloper); Hinged; Leopard; Unknown sp.

CHAPTER 4

Post-Release Success of Two Rehabilitated Vervet Monkey (*Cercopithecus aethiops pygerythrus*) Troops in KwaZulu-Natal, South Africa

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Abstract

There are regularly large numbers of vervet monkeys (*Cercopithecus aethiops pygerythrus*) in rehabilitation centres in KwaZulu-Natal, South Africa. This study evaluated the efficacy of releasing two vervet monkey troops into the wild according to methods employed by an established rehabilitation centre. Two troops were assembled over 2-3 years. Coloured ear-tags identified adults, sub-adults and juveniles. Radio-collars were placed on all the adults and sub-adults of both troops (41% of all individuals). Each troop was released at a suitable site after two nights in a holding cage, and supplementary food was provided for two months after release. For 10 months locations of both troops were recorded, as well as the presence/absence of individuals and their general behaviour. The smaller troop survived better than the larger troop, with only 4 of 35 individuals (11%) confirmed alive in the large troop compared with 12 of 24 (50%) in the small troop. The releases were not successful in terms of survival, as annual survival for wild vervet monkeys is much higher than that for the two troops, but were in terms of the troops not being dependent on humans, having established distinct home ranges, survival of an infant, and two births in the breeding season following release. Recommendations are provided for consideration in future releases of captive rehabilitated vervet monkeys.

Key Words: *Cercopithecus aethiops*, post-release monitoring, rehabilitation, radio-telemetry, South Africa, vervet monkey

Introduction

Primates are generally translocated for conservation purposes, namely reintroductions and re-enforcements, and/or for welfare reasons (e.g. release after confiscation). Wildlife re-introduction is an attempt to establish a species where it has become extirpated or extinct, while re-enforcement adds individuals to a declining population (IUCN, 2000; Baker, 2002). These translocations have involved wild-born individuals, including black howler monkeys, *Alouatta pigra* (Ostro et al., 1999; Horwich et al., 2002), and baboons, *Papio anubis* (Strum, 2002), but mostly captive-bred individuals, such as golden lion tamarins, *Leontopithecus rosalia* (Kleiman et al., 1986; Beck et al., 1991); black-and-white Ruffed lemurs, *Varecia variegata* (Britt et al., 2002); Gee's golden langurs, *Trachypithecus geei* (Gupta, 2002); and mandrills, *Mandrillus sphinx* (Peignot et al., 2008). However, many primate translocations have been for the improvement of the welfare of the individual (Baker, 2002; Cheyne & Brulé, 2004; Goossens et al., 2005). These have involved individuals from wildlife rehabilitation centres, whose goal is to enable a "displaced, sick, injured or orphaned wild animal" to "function normally and live self-sufficiently" once released (Anon., 2008).

There are a variety of primate species in rehabilitation centres and sanctuaries worldwide, such as guenon (*Cercopithecus sp.*), mangabey (*Cercocebus sp.*), gibbon (*Hylobates sp.*), bonobo (*Pan paniscus*), and common chimpanzee (*Pan troglodytes)*

(Carlsen et al., 2006). A few studies have documented post-release success of rehabilitated primates, including Bornean orangutan, *Pongo pygmaeus* (Grundmann, 2005); Műllers Bornean gibbon, *Hylobates muelleri* (Bennett, 1992), Lar gibbon, *H. lar* (Shanee & Shanee, 2007), agile gibbon, *H. agilis* (Cheyne et al., 2008); common chimpanzee, (Borner, 1985; Farmer & Jamart, 2002; Goossens et al., 2005); lowland gorilla, *Gorilla gorilla* (Pearson et al., 2007); and Guianan/Margarita Island brown capuchin, *Cebus apella* (Suarez et al., 2001).

In general, releases of these rehabilitated and captive-bred primates have been poorly documented (Gupta, 2002; Agoramoorthy & Hsu, 2006), or have resulted in high mortality, due to individuals being inadequately prepared for life in the wild, disease and/or hunting/theft by humans (Bennet, 1992; Borner, 1985; Hannah & McGrew, 1991; Beck et al., 1991). The successful releases were probably due to increased pre-release training (e.g. Shanee & Shanee, 2007) and post-release support. For example, an 8-year post-release survival of 62% of released chimpanzees would certainly have been lower, as 50% of released males would have died without veterinary intervention (Goossens et al., 2005).

In South Africa, the most common primate in rehabilitation centres is the vervet monkey (*Cercopithecus aethiops pygerythrus*). In 2005, an estimated 3000 were in such centres (Grobler et al., 2006). Vervet monkeys are social animals, living in mixed sexed groups ranging in size from 5 to 76 (Fedigan & Fedigan, 1988). They are widespread and abundant throughout Africa (Struhsaker, 1967; Skinner & Chimimba, 2005) and listed as "least concern" in the 2008 IUCN Red List of Threatened Species (IUCN, 2008), in contrast to the conservation status of primates monitored in previous studies, which are generally endangered or even critically endangered. However, vervet monkeys are admitted to rehabilitation centres for similar reasons to the endangered primates mentioned above, as they are either ex-pets (after either confiscation by conservation authorities or handed over by private individuals), found orphaned or injured (Whittsit, 1995; Rhind & Lawes, 1998). Generally they become orphaned or injured in suburbia due to either direct (e.g. home food-raiding and subsequent shooting) or indirect (e.g. vehicle collisions) conflict with humans (Henzi, 1979; Whittsit, 1995; Saville, 2007). There were once considered "vermin" in South Africa, and legally allowed to be killed (Henzi 1979; Grobler et al., 2006). This human-wildlife conflict is likely a result of the natural habitat of vervet monkeys' shrinking with an increase in housing developments, together with an increase in suitable habitat in suburban gardens, and lack of natural predators in these environments (Henzi, 1979; Whittsit, 1995). Even though there have been some attempts to minimise this conflict through education (e.g. Henzi, 1979; formation of non-government organizations like "Primates Africa"), vervet monkeys continue to enter rehabilitation centres in large numbers. Once in rehabilitation there is a reluctance to euthanase them, or hold them in captivity (Carnie, 2005), as this is contrary to the goals of rehabilitation, and thus they are released into the wild. Previous releases of rehabilitated vervet monkey were poorly monitored, but poor survival has been generally supposed (Whittsit, 1995). One scientific study has determined the post-release success of two troops of vervet monkeys from a rehabilitation centre, however monitoring of troops was limited, and success was determined after one week post-release for one troop, and one month for the other (Rhind & Lawes, 1998).

The present study was thus instigated to assist the local conservation authority, Ezemvelo KZN Wildlife (EKZNW), in investigating methods of release in an effort to improve post-release success, which would be used as a benchmark for future releases by incorporating them into an EKZNW document titled "Norms and Standards for Care and Management of Ex Situ Vervet monkeys *Cercopithecus aethiops* in KwaZulu-Natal". Our study therefore tested the efficacy of the release protocol developed by EKZNW and the rehabilitation centre. No previous reporting or documentation similar to this had been done due to lack of funding and resources made available for a common species. We assumed that the vervet monkeys had been successfully rehabilitated and the release site was suitable based on the rehabilitation centre feedback and on the EKZNW permit for permission to release. Therefore we expected the troops to successfully adapt to being released into the wild, but the degree of success would be dependent on troop size. Success was assessed in terms of a rescue/welfare release (Baker 2002), namely similarities in survival, reproductive success and home range establishment to wild troops in one year (Farmer et al., 2006; Cheyne et al., 2008). We expected that the larger rehabilitated vervet monkey troop would be more successful (e.g. higher survival) than the smaller troop, due to the larger group size offering protection from predators and greater advantage over foraging resources (Isbell et al., 1990). We could not test whether individuals with experience in the wild would be more successful than those who had been hand-raised, because individual histories were unknown.

Methods

Protocol and Study Animals

The captive monkeys were housed at the Centre for Rehabilitation of Wildlife (CROW), based in Durban, KwaZulu-Natal (KZN), South Africa. EKZNW, together with CROW, developed the protocols for the releases and subsequent feeding regimes for vervet monkeys in this study, and are detailed below. Relevant sections of the IUCN guidelines for reintroductions (IUCN, 1998) were included in release development plans. The protocol followed was a compromise between the local conservation authority and the rehabilitation centre. Those involved were doubtful of the applicability of great ape release protocols to an old world monkey such as the vervet monkey and thus were not used in developing the protocol. The monitoring study had ethical clearance from the University of KwaZulu-Natal.

Two troops of captive monkeys were released and monitored in this study. Troop 1 consisted of 35 individuals, with 5 adults (3 females), 9 sub-adults (2 females) and 21 juveniles, while Troop 2 consisted of 24 individuals, with 4 adults (1 female), 7 sub-adults (4 females), 12 juveniles and a 5-week old infant. Both troops were assembled over the previous 2-3 years in separate enclosures (30 x 20 m floor x 4 m high), which had various climbing structures for the vervet monkeys to use. The last monkey was added in July 2006 to Troop 1 (H. Fitchat, CROW, pers. comm.). Troops were formed using a group of adults and sub-adults, to which captive-raised juveniles were added (H. Fitchat, pers. comm.). Histories of individual monkeys were unknown because they were not individually marked on arrival at the rehabilitation centre. However, five in Troop 1 (2 sub-adult males, 2 adult females, 1 sub-adult female) and five in Troop 2 (1 adult male, 1 sub-adult male, 1 juvenile male and 2 adult females) had likely originated from the wild. The troops were considered cohesive and all individuals were considered ready for release (H. Fitchat, pers. comm.) CROW did not separate monkeys according to their source because there are no known significant geographical genetic differences in vervet monkeys found in South Africa (Grobler et al., 2006).

Pre-Release Measurements, Marking and Health Checks

We classified individuals as adults (> 4 yr and sexually mature), sub-adults (~ 3 - 4 yr), juveniles (0.5 - 3 yr), and infants (< 0.5 yr, Struhsaker, 1967). Five days before the release, a veterinarian captured all adults and sub-adults in each troop using a net and anaesthetised them with 0.5-1 ml ketamine hydrochloride (Ketamine, Kyron Laboratories, Johannesburg, South Africa). Once anaesthetised, age classes were confirmed using body mass (Table 1) and for males, age classes were additionally confirmed using the size of their testes (Henzi, 1982). Neck circumferences (Table 1) were determined for the correct attachment of radio-collars (see next section). Juveniles were not captured at this time, as radio-collars were not to be fitted due to growth issues. Because of welfare concerns, one adult female in Troop 2, which had a dependent infant, was also not captured at this time.

We marked the captive monkeys using one of three differently coloured 104 x 2.5 mm cable-ties (Insulok, Hellermann Tyton, South Africa) to indicate age class. The veterinarian inserted the cable-ties into an incision in the mid-ear, just above the cartilage, of each anaesthetised monkey. Alternate ears distinguished the two troops. Juveniles were given ear tags when they were caught for transport to the release site, while the mother was not marked. We fitted radio-collars only on to anaesthetised adults and sub-adults, so 24 of 59 monkeys had collars (40% Troop 1, 42% Troop 2). Each collar (locally made by C. Dearden, Pietermaritzburg) had a radio-transmitter with a unique frequency (~150 VHF range) and a 1/8 wavelength stainless steel tracer wire antennae powered by a lithium 3.5V AA battery, sealed in epoxy putty (Pratley (Pty.) Ltd, Gauteng, South Africa). The transmitter was attached with belting material and covered with heat-shrink tubing to prevent chaffing. Collars were 8mm wide while length depended on individual's neck circumference. The collars (with attached transmitters) weighed 43.1 g ± 2.0 (SD), < 4% of the vervet monkeys' body weight (Cochran, 1980). Collars were stitched using cotton (2 mm), so that they would fall off after about a year, as a consequence of wear.

To give an indication of the health status of the monkeys, the veterinarian took two blood samples (2 - 5ml each) from each anaesthetised monkey for haematological and biochemical analyses. VetDiagnostix Pathology Laboratory (Pietermaritzburg) analysed the blood samples and compared the results with standard blood values for vervet monkeys (or green monkey, *Chlorocebus aethiops,* synonymous with *Cercopithecus aethiops)* in the International Species Information reference range (ISIS: Teare, 1999). The veterinarian dewormed all monkeys with 0.2 - 0.4 ml of Invermectin (Ivomec, Merck (Pty.) Ltd., Midrand, South Africa) before they were returned to their enclosures to recover from the anaesthetic. Juveniles were dosed with the same dewormer on the day that they were caught for transport to the release site.

Timing and Data Collection

The two rehabilitated monkey troops were released in summer (17 and 22 January 2007 respectively), when potential food resources were likely to be the most abundant due to seasonal rainfall. Data were collected from release until January 2008, i.e. one year. Behavioural monitoring and radio-telemetry were conducted for 3 hr, in the morning and afternoon, every day (during January and February 2007) after release. Thereafter, the intensity and frequency decreased to once a week until August, and then to twice a month until December. Data were collected once in January 2008.

Release Site

The monkeys were released in Duma Manzi Private Game Reserve (30°02’S, 30°18’E, 5000 ha), near Richmond, KZN. Vegetation in the reserve is characterised as Eastern Valley Bushveld (Mucina & Rutherford, 2006), dominated by *Acacia karoo* and exotic *Melia azedarach*. The habitat mosaic within the reserve was diverse, providing food sources at different seasons, including fruit, flowers and leaves of *Acacia karoo, Ficus natalensis, Celtis africana, Strychnos spinosa* and of various *Rhus* and *Grewia* species (Pooley 1968; Foord et al. 1994). Furthermore, wild troops of vervet monkeys were present, which suggested that there was a suitable habitat for the species. There would also be opportunities for natural movement between the captive and wild troops (Henzi & Lucas, 1980; Cheney & Seyfarth, 1983) and the rehabilitated individuals would also have opportunities to learn natural foraging behaviour from wild monkeys (Strum, 2002). The landowner believed there to be low numbers of troops, possibly as a result of previous human occupation, and thus the habitat was likely below carrying capacity.

Within the reserve, the two release sites for each troop were chosen for their proximity to the river, ensuring adequate water availability throughout the year, and food availability in the riverine vegetation. The release site of Troop 2 was further from the river (about 210 m, along a dry river bed) than for Troop 1 (maximum 30 m from river), but was chosen because it was the closest area to the river with suitable habitat for vervet monkeys and it had shade for the holding cage. It had the additional benefit of having a fig tree (*Ficus natalensis*) nearby (a highly visible preferred food source: Pooley, 1968). These two sites were 1.2 km apart and separated by a large hill. Owing to the proximity to the river, there was much movement of rural people and their cattle through Troop 1's release site, the extent of which was not realised until after the release. The reserve manager and CROW had obtained support from the nearby local community for the release.

Soft Release

We used two soft release procedures to enable individuals to adjust to the new environment (Caldecott & Kavanagh, 1983; Bright & Morris, 1994; Baker, 2002). This included holding each troop in a metal weld-mesh holding cage (5.1 x 3.9 x 2.0 m) for two nights before release, and providing supplementary food for two months post-release.

The troops were taken in individual wooden animal transport boxes to the release sites, five days apart, and released into the holding cage. It was placed in the shade, with additional shade cloth covering the top. Enclosed in the cage were natural small shrubs, but extra branches were provided for the monkeys to climb on. A trough of water, and food trays of dry (seeds, nuts, dried fruit) and wet food (including butternut, apples) were provided in the cage until the monkeys were released. The food provided was similar to that given at CROW, but excluded some items such as eggs, bread and beans. The holding cage was left standing for 2 days after release of Troop 1 and then moved to the release site of Troop 2.

After release, the food was placed on three plastic food trays (600 x 400 mm) set up in trees about 4 m away from the holding cage with about 7 m between trays. Fresh food was provided in two and a half 10L buckets and dry food in approximately one bucket at 06h00 and 15h00 for the first 3 weeks after release for Troop 1. The morning feed coincided with the initiation of foraging at daybreak, while the afternoon feeding allowed foraging time prior to sunset, as found in wild troops (de Moor & Steffens, 1972). Twice-a-day feeding was limited to 2 weeks for Troop 2, so that the feeding regimen for both troops became synchronous. Thereafter, feeding was limited to mornings only. Intensity of feeding decreased every 9 days, from once-a-day feeding to every fifth day near the end of March. Quantity of food was subsequently reduced, as judged by the amount of food left over at the next feeding day. Supplementary feeding stopped at the end of March 2007. In addition to food, Troop 2 was also provided with a trough of water at the release site. Over 2 months, the trough was moved in small increments towards the river, to lead the troop to a more permanent water source. The post-release policy allowed for interventions if any individual was not adjusting or if it suffered from a life-threatening injury.

Monitoring Post-Release Success

Monitoring sessions alternated between morning and afternoon, and between troops. For the first 3 months, behavioural data were recorded when the monkeys were provided supplementary food and most easily seen at the feeding site. The focal troop was scanned every 15 min. and information was recorded on the number of monkeys seen, ear tag colour, behaviour (e.g. grooming, eating) and what they were eating. Once supplementary feeding was discontinued, behavioural observations were made once the troops were found using radio-telemetry, for approximately 1.5 hours.

For the first 2 months, the locations of the 22 collared monkeys were estimated using triangulation (White & Garrott, 1990). This meant that the direction of the strongest radio-telemetry signal for each monkey was obtained from two fixed posts, where each post had a 5-tier Yagi aerial attached to a wide-band scanning receiver (DJ-X10, Alinco Inc., Japan), which was secured on top of a protractor placed onto the ground and moved by hand. The intercept of the two directions recorded for one monkey is then an estimate of the monkey's location. However, the locations were severely compromised by "re-bound" (i.e. signals bounce back from a vertical surface from the wrong direction (Kenward, 2001)) and thus were excluded from further analyses. Therefore, after these 2 months until the end of the project, a 3-tier Yagi aerial and the same wide-band scanning receiver as used previously were used to locate the exact position of collared monkeys. Once they were found, we used a hand-held Global Positioning System (GPS) (12XL, Garmin Inc., USA) to record the correct positions of the respective troops. GPS locations were exported into Geographical Information System (GIS) ArcMap 9.2 (Environmental Systems Research Institute Inc., (ESRI), Redlands, California) for further analyses.

Data Analysis

Differences in pre-release body mass and neck circumferences between age groups in each troop were determined using Analysis of Variance (ANOVA) and a Scheffé post-hoc test if there was significance. When the data were not normally distributed, a Kruskal-Wallis

ANOVA was used. Significance of differences in age and sex between the troops in body mass and neck circumference were determined using Mann-Whitney U tests. Depending on whether the data were normally distributed, this test or a t-test was used to determine differences in pre-release blood test results between the two troops (presented in Appendix 1). A Wilcoxon Matched Pairs test determined significant differences between the number of monkeys seen during each monitoring session (the maximum “observed”) and the minimum number of monkeys alive in the troop, based on subsequent numbers observed in the troop (“actual”).

Even though radio-telemetry was used primarily to locate the troops after release to determine the survival of monkeys, we wanted to determine whether the troops established in an area, and so we estimated the area used by each troop using the data collected during the few hours of monitoring, which we termed a home range. Therefore, home ranges (95% kernels) and core ranges (50% kernels) were determined for each troop using one GPS location per monitoring day (including morning or afternoon) during March - November 2007, using Animal Movement Analysis extension (Hooge and Eichenlaub, 1997) for ArcView GIS 3.3 (ESRI Inc., California). Minimum convex polygons (MCPs) were estimated using Hawth’s Analysis Tools extension (Beyer, 2004) for ArcMap. To quantify the distance travelled in each season, the distance function in ArcMap was used to obtain the distance travelled per hour. Movement data were separated into three seasons, where autumn started on March 21, winter on June 21 and spring on September 23. To avoid autocorrelation, only distances travelled in the afternoon and in the last session of each month were used. Differences in hourly distance travelled between seasons were determined using repeated measures ANOVA (RMANOVA). T-tests were used to determine whether seasonal distance travelled differed between the troops. All statistical analyses were performed using Statistica 7 (StatSoft Inc., Tulsa, USA).

Results

Pre-Release Measurements

Adults and sub-adults of both sexes in Troop 1 showed no significant difference in body mass (Kruskal-Wallis ANOVA, $H_{(2, 11)} = 4.755$, $p = 0.093$), or neck circumference ($H_{(2, 11)} = 4.556$, $p = 0.103$) (Table 1). However, neck circumference (ANOVA, $F_{(2, 7)} = 7.081$, $p = 0.021$) and body mass ($F_{(2, 7)} = 8.655$, $p = 0.013$) differed significantly between adults and sub-adults in Troop 2 (Table 1). Adult males were significantly larger in mass than sub-adult females (Scheffé post-hoc test, $p = 0.013$) and had a greater neck circumference than sub-adult females ($p = 0.025$) and sub-adult males ($p = 0.075$) (Table 1). Comparisons between the troops showed that mass and neck circumferences (Table 1) did not differ significantly between sub-adult females (Mann-Whitney U test, mass: $z_{(2, 4)} = -1.389$, $p = 0.165$; neck: $z_{(2, 4)} = -0.926$, $p = 0.354$), adult males (mass: $z_{(2, 3)} = 1.732$, $p = 0.083$; neck: $z_{(2, 3)} = -0.289$, $p = 0.773$) or sub-adult males (mass: $z_{(7,3)} = -1.937$, $p = 0.053$; neck: $z_{(7, 3)} = -1.254$, $p = 0.210$). Adult females were not compared, as one adult female in Troop 2 was not measured because she had an infant. Similarly, no comparisons were made between juveniles, as data were only available for three in Troop 2.

Most of the blood parameters measured did not differ significantly between the two troops (Appendix 1). However, Troop 1 had higher number of basophils and higher urea levels compared with Troop 2, which had higher MCHC levels and creatine levels than Troop 1 (Appendix 1). Compared with the reference range (ISIS, Teare, 1999), the average platelets value for both troops were higher, while the average urea value for Troop 2 was lower (Appendix 1). Some individuals had blood variables that were outside this reference (Appendix 1), namely lower and higher platelet values (in both troops); higher leucocytes

(Troop 1), higher lymphocytes (both troops), higher creatine (Troop 2), higher albumin (Troop 1); and lower urea values (both troops) (Appendix 1).

Foraging Behaviour and Movement

From the day of release both troops ate natural vegetation as well as the supplementary food. They appeared not to depend on the supplementary food because they often did not finish it before leaving the area to forage elsewhere. Monkeys in both troops were seen eating exudates, pods, flowers and leaves of *Acacia karoo*; flowers of various forbs (e.g. *Dicliptura heturostegia*); various grasses; fruit of *Ficus sycomorus* and a tuber from an unidentifiable plant (only Troop 2). They were also seen to eat parts of various non-indigenous plants, namely: *Lantana camara* berries; syringa (*Melia azedarach*) leaves and fruit; *Chromalena odorata* leaves; and balloon vine (*Cardiospermum grandiflorum*) leaves and seeds. Both troops were seen eating insects, such as ants, grasshoppers and beetles, and may have been looking for other insects when actively looking under rocks.

With declining supplementary feeding frequency, monkeys in both troops filled their cheek pouches when food was provided. Over this time period, more individuals from Troop 2 approached research assistants and at times snatched food from them. Individuals in this troop also looked for food on the back of an open-backed food delivery vehicle. This behaviour ended once supplementary feeding terminated. However, the dominant male in Troop 1 seemed to be "human-imprinted" (permanent attachment to human (Sleeman, 2007)), as he approached research assistants for food from release and continued until after supplementary feeding ended.

Each troop travelled further in winter compared with autumn (Fig. 1), but this was not significant for Troop 1 (RMANOVA, $F_{(2,4)} = 3.814$, $p = 0.118$) or Troop 2 ($F_{(2,4)} = 2.806$, $p = 0.173$). There was also no significant difference in seasonal distance travelled between the troops (autumn: t = -1.611, df = 4, p = 0.182; winter: t = -2.644, df = 2, p = 0.118; spring: t = 0.286, df = 2, p = 0.802) (Fig. 1). However, Troop 2 had a larger home range than Troop 1, with 4.0 ha (MCP) and 10.5 ha (95% kernel home range) (Troop 2) compared with 2.4 ha (MCP) and 8.0 ha (95% kernel) (Troop 1). Core ranges (50% kernel) were similar at 1.9 ha (Troop 2) and 1.4 ha (Troop 1). Ten months after release, the troops had not combined, even though they were released relatively close to each other; and each range still included its respective release sites.

Interactions with wild troops

Following each release, after most of the troop has left the cage for the surrounding habitat, Troop 1 and Troop 2 vervet monkeys both fought with a wild troop. A few members of Troop 1 sustained injuries, especially the dominant male, but there were no visible injuries to individuals in Troop 2. The wild troop had not been seen before these encounters, and it is not known which troop initiated the contact. Encounters with wild troops occurred several times after this, but seemed to only result in vocalisations. A month after release, a wild, adult male was seen on the periphery of Troop 1. Similarly, about two days after release a wild adult male was seen on the periphery of Troop 2. By September, this or another wild adult male was seen sitting next to the dominant male.

Troop number fluctuations over the study period

The results shown in the Figures and Tables only include data to 11 November 2007 for Troop 1. Afterwards the troop was too skittish to be observed effectively and the last operational transmitter failed in January 2008. For Troop 2, the cut-off date was the 1 November 2007, because all the radio-transmitters had failed.

Numbers of monkeys per troop varied greatly between each monitoring session. There was a significant difference between the maximum number “observed” and the minimum number alive in each troop (“actual”), based on subsequent observations of the troops (Troop 1: Wilcoxon Matched Pairs Test, $z = 4.457$, $n = 41$, $p < 0.001$; Troop 2: $z = 4.703$, $n = 37$, $p < 0.001$). The “actual” number of monkeys was used in all analyses.

Troop 1 experienced an initial loss of 13 individuals one day after release (Fig. 2). Numbers decreased until 18 individuals remained at the end of the month and 15 individuals at the end of February (Fig. 2). Troop numbers then remained stable for five months, until a decrease at the end of July (Fig. 2). Thereafter, an almost steady decline occurred, until the troop consisted of four individuals (11%) after 10 months post-release (Fig. 2). Between 10-11 months after the release there were two births in Troop 1, one by an adult and another by an individual initially marked as a juvenile. In comparison, Troop 2 remained stable for the first two months, with no losses, followed by a decrease of four individuals in April (Fig. 2). Two periods of a few months stability followed, separated by a loss of four individuals in each troop in July and October (Fig. 2). After 10 months post-release, only 12 monkeys were confirmed to be alive (50%) in Troop 2 (Fig. 2). There were no births in Troop 2, although mating was observed.

Age-specific deaths and injury

The large decrease in Troop 1 a day after release (Fig. 2) was largely a consequence of 10 juveniles leaving the troop (Fig. 3). One adult and two sub-adults were also missing at this stage (Fig. 3). Subsequently, by the end of January, there were two adults, three sub-adults and 11 juveniles missing, with one confirmed dead juvenile female (Fig. 3). She died of a suspected snake bite, as indicated by the wounds on her body. In the beginning of February, an adult female was removed from the study and returned to captivity (Fig. 3), as she constantly approached the research assistants for food and/or companionship. She was diagnosed as "human-imprinted" and recorded for the purposes of analyses as "dead". Later in the same month a sub-adult male left the troop and was found living near a rural settlement about 2 km from release site. He was also recorded as "dead", as he was not part of the troop (Fig. 3). He was found dead 6 months later, presumably killed by humans, because his collar was found near to the settlements inside a half burnt plastic bottle. Three sub-adult males and one sub-adult female were preyed upon in February, March, April and May (Fig. 3), presumably by a raptor, as the location and type of remains suggested this. There were resident crowned eagles (*Stephanoaetus coronatus*), a known predator of vervet monkeys (Baldellou & Henzi, 1992) in the area. The last confirmed death in Troop 1 was of the dominant adult male in June (Fig. 3). Cause of death is unknown, but he was likely killed by humans, as his collar was found untied in the middle of the river, close to the release site. After 10 months post-release monitoring Troop 1 consisted of one adult female, one sub-adult male and two juveniles, with 23 (66%) individuals missing, i.e. two adults (female and male), three sub-adults (one female, two males) and 18 juveniles (Fig. 3).

In comparison to Troop 1, Troop 2 remained stable until April, when there were two sub-adults and two juveniles missing (Fig. 4). In June, one sub-adult male was found dead (Fig. 4), perhaps succumbing to injuries sustained in May. Other individuals were also seen with injuries in May, possibly due to fighting with a wild troop or intra-specific conflict. Two sub-adult females were found dead in July (Fig. 4), one appeared to be a raptor attack, but the cause of the other was unknown, as no remains, except the intact collar, were found. There were two probable deaths (unconfirmed, but recorded as dead) of a sub-adult male and sub-adult female, which occurred in October and November respectively (Fig. 4). The male had been sick (listless and thin, but still eating) for about 3 months before his disappearance, which suggests that he died from natural causes. The female was healthy and strongly bonded to the troop and so was probably killed by a predator (Cheney & Wrangham, 1986; Isbell et al., 1990). Therefore 10 months post-release, Troop 2 consisted of four adults (three males), one sub-adult male, six juveniles and the original infant, while seven individuals (30%) were missing (one female sub-adult and six juveniles) (Fig. 4).

We termed individuals as ‘missing’ when they could not be located at the end of the study period. This was largely due to the lack of individual identification, the lack of collars (juveniles), radio-collars failing (as early as 6 months after activation, even though the person who assembled the radio-collars gave an estimate of 12 –18 months), collars coming off (as early as 7 months, due to the cotton breaking) and the lack of mortality sensors on radio-collars (therefore the date of death was unknown).

Discussion

Were the Releases Successful?

Survival is the most basic indicator of a successful rehabilitation release because an ill-prepared animal would likely die soon after release due to a decrease in condition (Waples & Stagoll, 1997) or because it is easily predated (Beringer et al., 2004). When known mortality rate for wild individuals is considered (as suggested by Molony et al., 2006), the average of 22% dead in the two released monkey troops in one year was only slightly higher than the 15% dead recorded for wild vervet monkeys over the same time period (Cheney et al., 1988). However, if the “missing” animals were included, then the number of deaths increased to 86% (Troop 1) and 50% (Troop 2) and releases would therefore be failures in terms of low survival rate. Conversely, many deaths initially after release might be unavoidable, as annual mortality for a troop of wild vervet monkeys rose to 65% when they moved into a new area, as they were unfamiliar with the hunting behaviours of predators in the area (Isbell et al., 1990). In addition, the rehabilitated monkeys may have attracted the predator's attention by displaying erratic and more active behaviour than wild monkeys (Molony et al., 2006), especially around the supplementary feeding areas.

If the success of the vervet monkey releases is assessed in terms of reproduction (Seddon, 1999; Wolfaardt & Nel, 2003), since animals usually only reproduce when conditions are suitable (Wolfaardt & Nel, 2003), then the Troop 1 release was successful. Even though there were no births in Troop 2, it was significant that the infant survived (Cheney et al., 1981), because the first year is often the period of highest mortality (Cheney et al., 1988), where 57% infants do not survive the first year in wild Kenyan vervet monkey troops (Hauser, 1988).

Success indicators specific to a "rescue-welfare" release revolve around whether the animal is able to integrate socially into a local wild population (Waples & Stagoll, 1997), and behave similarly to a wild animal (Box, 1991), or by the establishment of released rehabilitated individuals in an area (Ostro et al., 1999), and the lack of dependency on humans for food (Cheyne & Brulé, 2004) and/or companionship (Grundmann, 2005). Two separate releases of rehabilitated chimpanzees were judged as successful based on factors other than survival (mortality was 38% (Goossens et al., 2005) and 90% in the other (Borner, 1985)), such as successful breeding, independence from human support (Borner, 1985) and integration with wild conspecifics (Goossens et al., 2005). Both released troops of vervet monkeys established in the area and remained separate, so each was successful in this respect. These areas were less than home ranges of similarly sized groups studied in the same province (KZN) (de Moor & Steffens, 1972). This suggests the troops were released into good quality habitat, as indicated by home ranges of wild troops (de Moor & Steffens, 1972). However, it is likely that the releases were not monitored for long enough for them to have established a bigger territory (Ostro et al., 1999), and/or the intensity of monitoring may have been insufficient to adequately calculate home range (White & Garrott, 1990). Furthermore, the presence of wild troops in the area may have prevented the two troops from expanding their ranges further (Cheney et al., 1988).

The rehabilitated vervet monkeys ate similar food items to those eaten by wild ones. These included the fruit of *Ficus sp.*; leaves, flowers, and exudate of *Acacia sp.*, grasses (Pooley, 1968), fruit of vines, and insects (Skinner & Chimimba, 2005). They showed a natural curiosity for trying new food items, and seldom seemed dependent on the supplementary food provided, indicating a successful release (Cheyne & Brulé, 2004). The troops showed similar foraging patterns to wild troops (de Moor & Steffens, 1972) where there was increase in the distance moved (over an hour of foraging) in winter compared with autumn, due to food restriction (Apps, 1992). However, the individuals in Troop 2 that snatched food from the research assistants, and the dominant male, adult female (that was returned to captivity) and the sub-adult male (who went to live near the rural settlement) in Troop 1 were failures of the release in terms of being dependent on humans (Cheyne & Brulé, 2004; Grundmann, 2005).

Fate of missing individuals

It is likely there was a high mortality of the juveniles that were missing. They were probably inexperienced because of their age, and perhaps due to their time in captivity, to watch for predators while foraging. Juveniles are more likely than other age groups to react inappropriately to predators (Seyfarth & Cheney, 1980) and only about 27% of female vervet monkeys survive to breeding age in wild troops in Kenya (Cheney et al., 1988). It was unusual for so many individuals to leave Troop 1 in a group and within a day after release, in comparison to that reported for wild troops (Henzi & Lucas, 1980). Group fission occurs in wild troops when the competition for resources becomes too great (Hauser et al., 1986), not when greater resources in a larger space are provided in the release. Furthermore, lone sexually mature males (not juveniles) would usually leave their troop to join another troop to increase mating opportunities (Isbell et al., 1990), or to increase their social rank (Cheney & Seyfarth, 1983), once they know the whereabouts and have interacted with another troop (Henzi & Lucas, 1980; Cheney & Seyfarth, 1983). Therefore, a likely explanation for the group leaving Troop 1 is because of the interaction with the wild troop upon release (Kleiman, 1996) and the troop not being cohesive. Troop 2 may have been more cohesive than Troop 1, possibly as a result of Troop 2 having an infant (Basckin & Krige, 1973; Skinner & Chimimba, 2005; Gusset et al., 2008), or having fewer juveniles, comparable to numbers in wild troops (2 to 10: Isbell et al., 1990). Furthermore, Troop 2 was small in size, comparable to those in the wild (average 26: de Moor, 1970; Fedigan & Fedigan, 1988) and had a greater female to male ratio (Hill & Lee, 1988). However, individual histories may also have been an influencing factor. This factor may have influenced individuals fleeing immediately after release in other primate studies (e.g. chimpanzees, Goossens et al., 2005).

Management implications

We suggest that all vervet monkeys entering rehabilitation centres should be marked for individual identification, as suggested in Guidelines for Non-human Primate Re-introductions (Baker, 2002). Records on each individual could then be kept, with details on each monkey’s history (e.g. whether it was orphaned, captive-raised, wild), its health (including results of blood tests), and any behaviour problems (e.g. tameness, aggressive) while in captivity. Individual identification, records and pre-release observations would enable individuals to be excluded if they do not meet the requirements for release or if they prevent troop cohesion. Furthermore, post-release behaviour and survival could then be better assessed. Individual identification would also allow for better health monitoring and assessment.

The ISIS reference range is less useful in assessing the health of a monkey than that monkey's own previous blood test, because of the small number of monkeys (maximum of 26 monkeys) that were used to develop the range (J. Hill, Vetdiagnostix Pathology Laboratory, pers. comm.). Consequently no definite conclusions were made on the health status of monkeys released in our study, although blood results showed that there were individuals that had blood variables outside the normal range, such as low urea values, indicating possible anorexia (J. Hill, pers. comm.). Therefore, as practically possible, regular blood samples should be obtained from each monkey, starting from admittance to the centre, to monitor health and diagnose possible diseases or diet deficiencies (Baker, 2002). They should be tested for the diseases known to affect this species (e.g. Kaschula et al., 1978), because of the negative affects on the individual's welfare, and on the wild vervet monkeys in the released area (Cunningham, 1996; Baker, 2002). As with diseased or health compromised individuals, psychologically unwell individuals should not be released, as suggested in a study on chimpanzees (Tutin et al., 2001). Particularly for vervet monkeys, those that solicit grooming or groom humans; seek human support or blanket/toy when stressed; climb on or bite humans should not be released. These behaviours were seen in the previously documented vervet monkey release (Rhind & Lawes, 1998) and in this study. As release sites for vervet monkeys are limited in availability (H. Fitchat, pers. comm.), with the likelihood of the site being in close proximity to humans, the possibility of conflict with people increases if there are humanised individuals in the troop (e.g. Borner 1985). Furthermore, to improve troop cohesiveness post-release we suggest that the number of juveniles (maximum of 12) and the size of the troop (maximum of 24) is limited, but further research is required to determine the extent that these variables affect success.

As the holding cage and/or supplementary feeding resulted in the troops remaining near the release site compared with the immediate flight of monkeys in previous undocumented releases from CROW (J.M. Harris, EKZNW, pers. comm.), these methods are recommended in future releases. Further research should investigate the effect of increased duration in holding cages, and of supplementary feeding. The latter and timing of release for the beginning of the wet season (October), when there is an abundance of food items, may support newly-released animals when they are able to only source sub-optimal food in the area (Bright & Morris, 1994; Csermely, 2000). In addition to having suitable food and habitat availability, location of a release site must consider proximity and density of wild troops. Rehabilitated vervet monkeys should be released near wild troops, as home ranges are usually adjacent to each other (Cheney et al., 1988), and it has been shown to be beneficial to encourage territorial behaviours in another release of a rehabilitated primate (gibbons, Shanee & Shanee, 2007). However, this may have a negative impact on food resources and behaviour of wild troops in the area (Caldecott & Kavanagh, 1983; Yeager, 1997), especially if carrying capacity is reached (Brambell, 1977). In addition, released captive individuals may be injured or killed by wild conspecifics, as seen in released rehabilitated gibbons (Bennett, 1992; Cheyne & Brulé, 2004), orangutans (Yeager, 1997) and chimpanzees (Goossens et al., 2005). In our study, the release event was stressful, as troops had encounters with wild conspecifics that resulted in some injuries. We therefore suggest that the carrying capacity of the release area be determined before any vervet monkey troops are released in the area.

It is essential that post-release monitoring of rehabilitated vervet monkeys is conducted to determine their fate. In particular, we suggest that post-release monitoring includes all individuals in a troop, that they all are marked for individual identification (e.g. ear tagging) and each fitted with radio-transmitters (preferably with mortality sensors) to locate them for a minimum of a year post-release, as it was impossible to find the monkeys that did not have radio-transmitters, or if their radio-transmitters had failed. Actual locations of troops or lone individuals should be recorded using a GPS. If triangulation is required, sources of error, such as signal re-bound, should be investigated before release.

Our recommendations for rehabilitated vervet monkey troop releases may be relevant to other primate species, for instance, the importance of releasing a socially cohesive group. This was also noted in a release of confiscated capuchins (Suarez et al., 2001). Furthermore, similar to that observed in our study, in a release of rehabilitated chimpanzees, some fled the release site immediately after they were released (Goossens et al., 2005). Other releases of rehabilitated primates also had individuals that were unable to adapt to being released (e.g. chimpanzees: Hannah, 1986, in Hannah & McGrew, 1991; golden lion tamarin: Beck et al., 1991; orangutan: Yeager, 1997). However, we need to emphasise that as primates vary in body mass, troop size, home range and habitat, only some of our recommendations are relevant to other species. Another important factor to consider is that most other primates that have been released are either critically endangered (e.g. lowland gorilla, black-and-white Ruffed lemur), endangered (e.g. golden lion tamarin, Gee’s golden langur, common chimpanzee, gibbon (various sp.), Bornean orangutan), or threatened (e.g. mandrill), while the vervet monkey is listed as least concern (IUCN, 2008). Consequently, the survival and reproduction of other primate species could contribute to the conservation of the species, while the release of a common species, such as vervet monkeys, may overburden an already saturated environment. Conversely, there is a greater concern for the possible negative effects of releasing rehabilitated animals into populations that are in peril, compared to those that are stable (Moore et al., 2007). Furthermore, because of the higher conservation status, the release of those primate species is likely to have more funding and staff available for lengthy pre-release training and/or soft-release (e.g. 15 months for gorillas: Pearson et al., 2007, 11 years for chimpanzees: Goossens et al., 2005) and intensive post-release support (e.g. guiding chimpanzees where to forage: Hannah, 1986, in Hannah & McGrew, 1991). Thus, methodology for release of captive primates is difficult to generalise.

Conclusion

Success of wildlife translocations is difficult to determine and can be said to depend on the goals of the project (Kleiman, 1989; Fischer & Lindenmayer, 2000). As the aim of releasing rehabilitated vervet monkeys is to improve the individual's welfare, and not the species, some may argue that such a release failed unless all individuals survived. Conversely, others may argue that any survival in the wild post-release is a success. Consequently success in terms of survival in our study was difficult to evaluate, but because there were a number of deaths and many missing individuals whose fate was presumed, we believe that the releases were unsuccessful in this respect. However, the two troops (including an infant) survived, were independent of human food provision and companionship, had established in an area, and had subsequent births in the breeding season following release, which were indicators of success. Contrary to our expectations, we consider the release of Troop 2 more "successful" than Troop 1, probably as a consequence of better troop cohesion. Unfortunately, the influx of monkeys into rehabilitation centres in South Africa remains unabated. Unless improvements are made to increase success of future releases of rehabilitated vervet monkeys and to minimise potential threats to wild population (e.g. disease), euthanasia and life-time care in captivity may be seen as better options (IUCN, 2000).

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TABLE 1. Average (± SD) body mass (g) and neck circumference (mm) and number of individuals (n) for Troop 1 (a) and Troop 2 (b). No measurements were recorded for one adult female and her infant in Troop 2 and juveniles in both troops, except three in Troop 2.

a)

Age class and gender	n	Body mass (g)	Neck circumference (mm)
Adult female	3	3174.0 ± 25.1	200.7 ± 19.1
Sub-adult female	2	2511.5 ± 115.3	165.0 ± 7.1
Adult male	2	5200.0 ± 282.8	230.0 ± 21.2
Sub-adult male	7	2580.0 ± 450.9	166.1 ± 12.3
Juveniles	21	N/A	N/A
Infant	0		

b)

Age class and gender	n	Body mass (g)	Neck circumference (mm)
Adult female	1	N/A	N/A
Sub-adult female	4	2817.5 ± 273.1	173.3 ± 13.6
Adult male	3	4253.3 ± 748.9	231.7 ± 27.5
Sub-adult male	3	3356.7 ± 210.8	184.0 ± 22.7
Juveniles	12	2856.7 ± 540.5 (n = 3)	170.7 ± 11.4
Infant	1	N/A	N/A

Figure legends

Fig. 1. Average distance (± SE) travelled by Troop 1 (solid line) and Troop 2 (dotted line) in one hour in the afternoon during 3 days in autumn (April, May, June), 2 days in winter (July, August) and 2 days in spring (September, October).

Fig. 2. Actual number (minimum in the population) of vervet monkeys in Troop 1 (solid line) and Troop 2 (dotted line) since release on 17^{th} (Troop 1) and 22^{nd} January 2007 (Troop 2) until last possible observation on 1^{st} (Troop 2) and 11^{th} November 2007 (Troop 1).

Fig. 3. Number of vervet monkeys in Troop 1 alive (striped bar), dead (black bar) and missing (white bar) in each age group (a: adults, b: sub-adults, c: juveniles) at the end of each month, after the troop was released in January.

Fig. 4. Number of vervet monkeys in Troop 2 alive (striped bar), dead (black bar) and missing (white bar) in two age groups (a: sub-adults, b: juveniles) at the end of each month, after the troop was released in January. Note that all four adults and the one infant survived the duration of the study period.

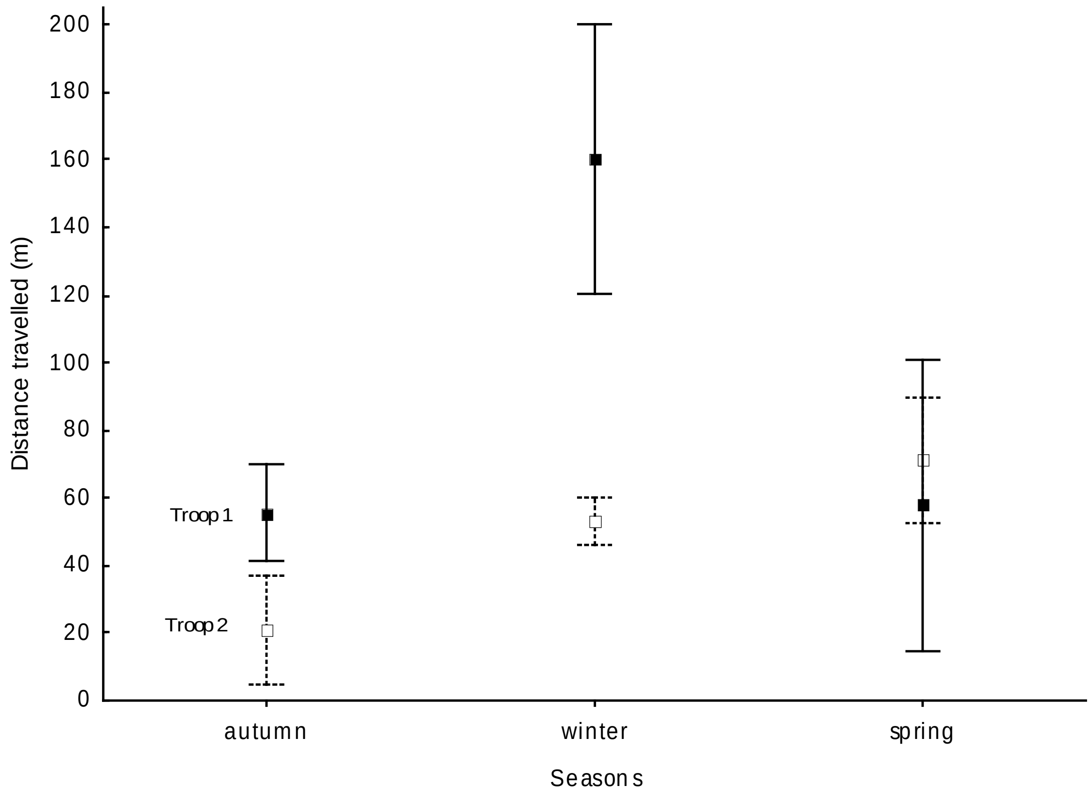

Fig. 1. Average distance (± SE) travelled by Troop 1 (solid line) and Troop 2 (dotted line) in one hour in the afternoon during 3 days in autumn (April, May, June), 2 days in winter (July, August) and 2 days in spring (September, October).

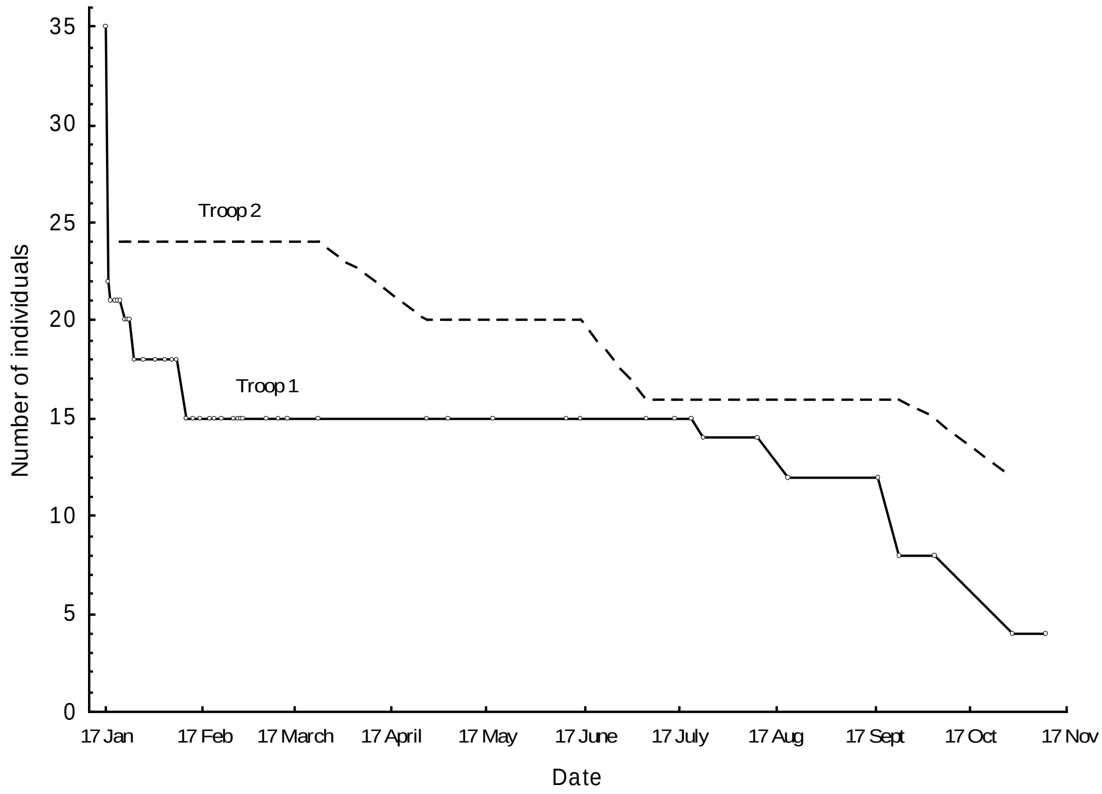

Fig. 2. Actual number (minimum in the population) of vervet monkeys in Troop 1 (solid line) and Troop 2 (dotted line) since release on 17th (Troop 1) and 22nd January 2007 (Troop 2) until last possible observation on 1st (Troop 2) and 11th November 2007 (Troop 1).

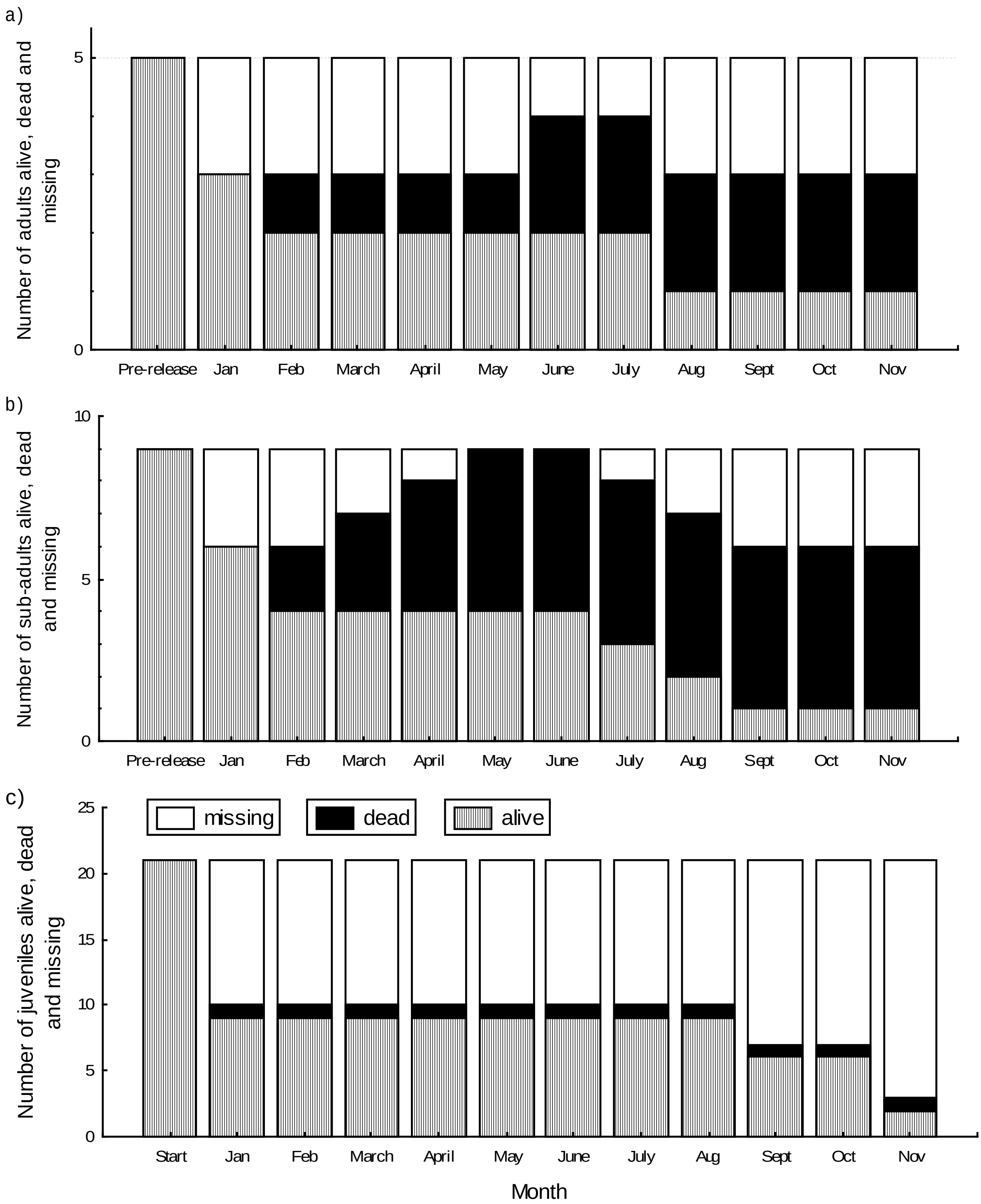

Fig. 3. Number of vervet monkeys in Troop 1 alive (striped bar), dead (black bar) and missing (white bar) in each age group (a: adults, b: sub-adults, c: juveniles) at the end of each month, after the troop was released in January.

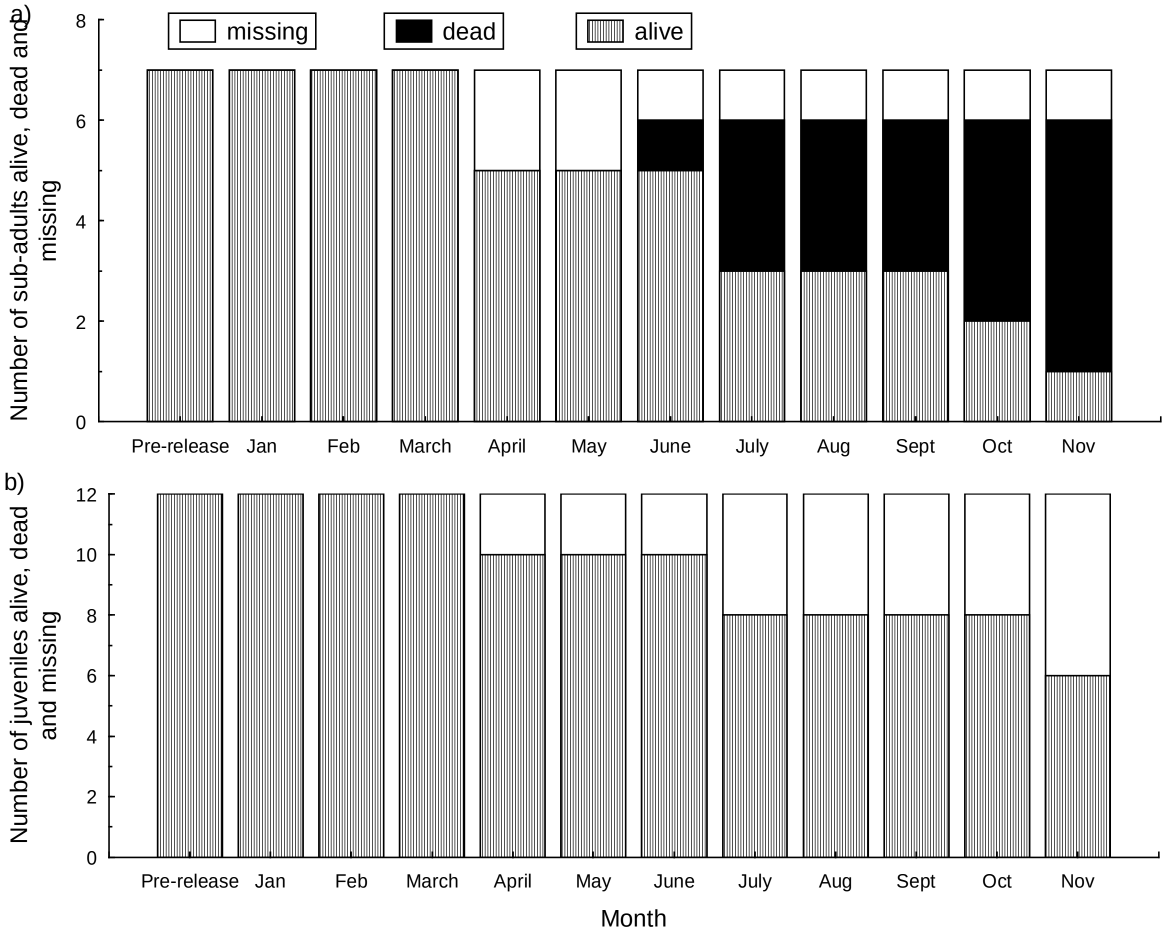

Fig. 4. Number of vervet monkeys in Troop 2 alive (striped bar), dead (black bar) and missing (white bar) in two age groups (a: sub-adults, b: juveniles) at the end of each month, after the troop was released in January. Note that all four adults and the one infant survived the duration of the study period.

Appendix 1. Pre-release haematological and biochemical blood results of all sub-adults and adults in both troops. Blood variable values that are outside the ISIS (1999) reference range are underlined in the table, while the symbol * indicates significant difference (Mann-Whitney U or t-test) between the average values for each troop.

Blood variables (units)	Reference range	Troop 1		Troop 2		Statistical analyses
		Mean	Range	Mean	Range	
Haemoglobin (g/dL)	8.8 - 18.9	12.12	10.90 - 13.90	13.20	10.00 - 16.80	t= -1.67, df = 17, p = 0.11
Red blood cells (x10^12/L)	4.4 - 7.3	4.98	4.49 - 5.64	5.39	4.33 - 6.49	t= -1.84, df = 17, p = 0.08
Haematocrit (L/L)	0.31 - 0.56	0.39	0.34 - 0.44	0.41	0.32 - 0.53	t= -0.62, df = 17, p = 0.54
MCV (fL)	60.1 - 95.7	79.10	74.00 - 85.70	75.49	67.90 - 81.60	t= 1.94, df = 19, p = 0.07
MCH (pg/cell)	16.0 - 34.4	24.34	23.30 - 25.30	24.42	22.40 - 26.40	t= -0.18, df = 17, p = 0.86
MCHC (g/dL)*	20.9 - 37.9	30.83	28.60 - 33.80	32.38	30.90 - 33.90	t= -2.54, df = 17, p = 0.02
Platelets (x10^9/L)	317.0 - 321.0	348.70	69.00 - 568.00	375.00	263.00 - 524.00	t= -0.50, df = 17, p = 0.63
Leucocyte count (x10^9/L)	2.6 - 20.0	14.20	8.41 - 25.93	10.92	6.67 - 19.65	t= 1.55, df = 17, p = 0.14
Neutrophils (x10^9/L)	0.06 – 17.2	6.37	3.65 - 9.44	5.17	1.86 - 16.70	t= 0.75, df = 17, p = 0.46
Lymphocytes (x10^9/L)	0.12 - 6.76	5.95	2.88 - 14.59	4.10	1.89 - 7.98	$z_{(10, 9)}$= 1.31, p = 0.19
Monocytes (x10^9/L)	0.05 - 7.96	0.28	0.15 - 0.56	0.24	0.11 - 0.49	t= 0.68, df = 17, p = 0.50
Eosinophils (x10^9/L)	0.03 - 3.73	1.28	0.40 - 2.77	1.23	0.12 - 3.04	t= 0.13, df = 17, p = 0.90
Basophils (x10^9/L)*	0.03 - 0.18	0.17	0.10 - 0.37	0.00	0.03 - 0.13	$z_{(10,9)}$= 2.69, p = 0.01,
Reticulocytes (x10^9/L)	10.0 - 100.0	80.20	21.00 - 155.00	81.67	54.00 - 119.00	t= -0.11, df = 17, p = 0.91
Urea (mMol/L)*	3.57 - 12.5	5.46	2.00 - 7.50	3.43	2.10 - 5.30	t= 3.38, df = 21, p < 0.01
Creatine (mmol/l)*	27.0 – 133.0	58.36	26.00 - 99.00	87.89	60.00 - 161.00	t= -2.71, df = 21, p = 0.01
Alkaline phosphatase (U/L)	24.0 – 1243.0	437.71	109.00 -722.00	544.60	121.00 - 1130.00	t= -0.95 df = 22, p = 0.35
Alanine aminotransferase (U/L)	9.0 – 388.0	24.92	4.00 - 44.00	30.50	15.00 - 80.00	$Z_{(13, 10)}$= -0.16, p=0.88
Total protein (g/L)	58.0 – 71.0	63.29	56.00 - 72.00	65.10	60.00 - 69.00	t= -1.14, df = 22, p = 0.27
Albumin (g/L)	36.0 – 51.0	45.21	36.00 - 61.00	46.50	43.00 - 52.00	$z_{(14,10)}$ = -1.52, p=0.13

CHAPTER 5

Can Rehabilitated Leopard Tortoises, *Stigmochelys pardalis*, be Successfully Released into the Wild?

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ABSTRACT.- Babcock's leopard tortoises (*Stigmochelys pardalis babcocki*) are taken to rehabilitation centers in KwaZulu-Natal province, South Africa, because they are either escaped, unwanted, or confiscated pets or else are confiscated from persons who acquire them illegally from the wild. South African rehabilitation centers are reluctant to euthanize tortoises and there are few tortoise sanctuaries. Consequently, the local conservation authority, Ezemvelo KZN Wildlife, developed a release protocol based on IUCN guidelines, to facilitate the release of rehabilitated *S. p. babcocki* into the wild. The present study was done to determine whether rehabilitated animals could be successfully released into the wild, judged by whether individuals were able to survive in the wild. Seventeen apparently healthy individuals greater than 100 mm carapace length that had been in captivity for longer than 2 months in a large rehabilitation center were released into the wild. These rehabilitated animals with attached radio-telemeters were hard-released at two different sites within the historical range of the species and monitored over a year. One of the tortoises was returned to captivity because of disease, three were killed

intentionally or accidentally by humans, one died probably due to being overturned by another animal, three others died due to a combination of disease, starvation and/or dehydration, and the fate of six were unknown. Since only two animals survived 13 months after release at one of the sites and only one was known to have survived 25 months after release at the other site, rehabilitated *S. p. babcocki* were not successfully released into the wild. However, recommendations to improve the probability of success of future releases of rehabilitated *S. p. babcocki* into the wild are provided.

Key Words. - Reptilia, Testudines, Testudinidae, *Stigmochelys pardalis babcocki*, tortoise, rehabilitation, release into the wild, post-release monitoring, South Africa

As with mammals and birds (e.g. Griffith et al. 1989), reptiles and amphibians have been translocated (Dodd and Siegel 1991) to establish a species in an area where it used to exist (“re-introduction”), to add individuals to an existing population (“supplementation”), to release a species into an area outside its historical range (“introduction”) (IUCN 1998) or to move individuals from an area where they are threatened, to an area where their habitat is secure (“relocation”) (Dodd and Seigel 1991). Success of these translocations is defined as the establishment of a self-sustaining population (Dodd and Siegel 1991), obtained by the survival and breeding of the released individuals, and persistence of this new population (Seddon 1999).

Wildlife rehabilitation is a type of translocation, but with different goals to those listed above, as it is “providing temporary care to injured, ill and orphaned wild animals with the goal of releasing them back into their natural habitat” (Anon 2008). Thus a successful rehabilitation release is when the released individuals integrate with the resident wild population, can survive without human aid or comfort (Waples and Stagoll 1997) and when all the released individuals die of old age (Ashton and Ashton 2008).

Because the IUCN would rather have confiscated animals placed in life-time care in captivity or euthanized than released, owing to the possible negative effects of the individual on the environment and the low success rate of released individuals (IUCN 2000), there is a need for thorough post-release monitoring of all rehabilitated animals. However, this is seldom done by the rehabilitation centers themselves (Hartup 1996; Fajardo et al. 2000). There are only a few published studies on post-release success of rehabilitated reptiles, mainly freshwater turtles (e.g., *Chrysemys picta*, *Chelydra serpentina*, *Trachemys scripta*, *Pseudemys rubriventris*; Saba and Spotila 2003) affected by oil spills. Some studies have included rehabilitated terrestrial chelonians (e.g. individuals kept as pets), namely box turtles (*Terrapene carolina*; Belzer 1999; Cook 2004) and gopher tortoises (*Gopherus polyphemus*; Lohoefener and Lohmeier 1986), to repopulate an area with these species. The main problem in these releases was similar to that in other tortoise relocation studies (e.g. Field et al. 2007; Hester et al. 2008), namely lack of site fidelity by released tortoises. However, deaths have also been the result of disease (Cook 2004), accidents (e.g. killed by house cat, Hester et al. 2008) and drought (Field et al. 2007), such that annual known survival of relocated radio-telemetered tortoises has ranged between 50% (out of 10 box turtles; Hester et al. 2008) and 68% (out of 28 desert tortoises, *Gopherus agassizii*; Field et al. 2007).

In South Africa, tortoises are brought to wildlife rehabilitation centers because they are either escaped or unwanted or confiscated pets, or else they are rescued from the indigenous medicine trade (Centre for the Rehabilitation of Wildlife; CROW). The options available to these tortoises are either a life-time in captivity, euthanasia or release (IUCN 2000). However, there are not enough suitable tortoise sanctuaries or residential properties of large enough size to provide the necessary requirements of tortoises in captivity, and keeping tortoises in captivity may encourage other people to acquire tortoises as pets. Rehabilitation centers in South Africa are reluctant to euthanize tortoises because this is contrary to their aims. As a result, tortoises are released into the wild without reference to a documented release protocol and with no consistent post-release monitoring. For these reasons the KwaZulu-Natal (KZN) provincial conservation authority, Ezemvelo KZN Wildlife (EKZNW), developed a release protocol in an attempt to increase the probability that the release of rehabilitated tortoises would be successful while minimizing risks to biodiversity.

In addition to testing the efficacy of this release protocol, this study was initiated to provide the first documented post-release monitoring of rehabilitated South African tortoises. We decided to monitor the release of Babcock's leopard tortoise (*Stigmochelys pardalis babcocki*) (Fitz and Havas 2006) at two different localities, as this species of tortoise is the most frequently admitted to a large rehabilitation center in KwaZulu-Natal. The aim of this study was to determine whether rehabilitated *S. p. babcocki* could be successfully released into the wild. Whether the release was successful or not was assessed in terms of the aims of a rehabilitation (and not a reintroduction) release, namely survival (Waples and Stagoll 1997), site fidelity (which is linked to survival; Burke 1989) and causes of death, whether natural or as a result of other factors (e.g. not adjusting to release).

METHODS

Listed below is the summary of the protocol developed by EKZNW for the release of captive tortoises into the wild (Armstrong 2003, 2005), which follows the IUCN/SSC

Guidelines for Re-introduction (IUCN 1998). All captive *S. p. babcocki* came from the Centre for Rehabilitation of Wildlife (CROW) in Durban, KZN.

Pre-Release. — Tortoises deemed suitable for release were those that had been at CROW for more than two months, to allow for any latent diseases to appear and be treated, and to wean them off a captive diet. Tortoises also had to be larger than 100 mm in carapace length to increase their chance of being able to withstand attempted predation. Since only the subspecies *S. p. babcocki* can be released in KZN, various morphological indicators were used to separate it from *S. p. pardalis,* which is found only in the Western Cape and Namibia (Loveridge 1935), and from putative hybrids of the two subspecies. Even though many authors do not recognize the two subspecies (e.g. Branch 1998; Boycott and Bourquin 2000), there is genetic and epidemiological evidence to suggest that there is a difference (Lambiris 1998; Varhol 1998, Le et al. 2006). Shortly before release, those tortoises selected for release were deemed fit for release by a herpetologist, being certified free of injuries, transmittable diseases, abnormal loads of parasites and foreign parasites (see Armstrong 2005). Each *S. p. babcocki* was then fitted with a locally-manufactured radio-telemeter onto the rear of its carapace using dental acrylic. The position of the radio-telemeter on the carapace was to prevent the possibility of the tortoises catching on vegetation or being unable to get under cover. This method has been used successfully in a previous study monitoring the movements of leopard tortoises in the Nama-Karoo, South Africa (McMaster and Downs 2009). Each radio-telemeter had a unique frequency (150 VHF) with a 1/4 wavelength stranded stainless steel tracer wire antenna (plastic coated) powered by a lithium 3.6V AA battery that was sealed in a slightly flexible rubber coating (ColourGuard, Loctite, USA). The radio-telemeters transmitted for 12 hours each day. Battery life was unknown but was estimated by the person who assembled the radio-telemeters to be between 12 and 18 months.

Study Animals. — For the first release, in January 2005, 22 *S. p. babcocki* out of 44 *S. pardalis* (11 males, 11 females) at the rehabilitation center were deemed suitable for release. The rest were either putative hybrids (7), females that had been placed in the same enclosure as putative hybrid males that may have subsequently mated with them (12), or were not certified as fit-for-release (3). One of the latter three had an upper respiratory tract infection, while the other two had ticks. Since only 10 (5 males, 5 females: L1-L10) out of the 22 were regularly monitored after release (because they had radio-telemeters attached), further detail for the other 12 individually marked and identifiable tortoises is not provided except where considered important. Resightings of the latter 12 were non-existent or very irregular. The 10 post-release monitored tortoises were mostly medium-sized, measuring between 263 and 313 mm straight carapace length and weighing between 2.5 and 4.5 kg, while one was larger at 424 mm and 6.0 kg (Table 1). The movements of a large wild female *S. p. babcocki* (LW, Table 1) were also monitored, after finding it opportunistically in the reserve and attaching a radio-telemeter on to its carapace in a similar manner as described.

For the second release, in December 2006, five *S. p. babcocki* out of 16 *S. pardalis* at the rehabilitation center, namely three females (T1 - T3) and two males (T4, T5), were deemed suitable for release. The rest were putative hybrids (8), or too small to be identified to subspecies (3). In February 2007, only two female (T6, T7) *S. p. babcocki* out of 18 *S. pardalis* at the rehabilitation center were deemed suitable for release. The rest were putative hybrids (9), or too young to be identified to subspecies (6), while one female had been in a putative hybrid male enclosure. Most of the tortoises were of medium size, with straight carapace length between 255 and 328 mm and weighing between 2.8 and 5.0 kg (Table 2). Tortoise T3 was the largest (463 mm, 15.3 kg) and T6 was the smallest (181 mm, 1.2 kg) (Table 2).

All *S. p. babcocki*, except T6, were termed adults, as they had plastron lengths of over 200 mm (Douglas and Rall 2006). An estimate of age was determined using the curves produced by Hailey and Coulson (1999). Thus all, except T3 and L7, were between 6 and 15 years old. T3 was estimated to be 75 years old because this was the age of a similar sized (483 mm carapace length, 13.2 kg) captive leopard tortoise (Boycott and Bourquin 2000). L7 was of similar size to T3 but half the mass, and therefore may have been younger. Besides T1 (confiscated from the traditional medicine trade), most of the *S. p. babcocki* were escaped pets, as they would not naturally be found in the suburbs of Durban. In addition, most had distorted carapaces (e.g. pyramiding of scutes), which is an indication of a tortoise raised on a "captive" diet (Gerlach 2004).

Selection of Suitable Release Sites. — Various criteria are important for choosing release areas (Armstrong 2003). The release areas should be within the native range of *S. p. babcocki* and should have had a population of the same species in the past but should have few or no *S. p. babcocki* at the time of the release. The factors that caused the decline in the tortoise population in the release areas should be known and no longer operating or else should be under long-term control. The region surrounding each release area should have suitable habitat for dispersal of the tortoises or their offspring, should the population exceed the carrying capacity of the release area. Suitable habitat for leopard tortoises is bushland, savanna, open woodland and grassland (including vleis) with relatively sparse ground cover (Greig and Burdett 1976; Rall 1985; Bourquin 1990; Boycott and Bourquin 2000). The release site should have suitable refuge sites present, which for leopard tortoises consist of dense undergrowth of trees and shrubs, thickets and vegetation clumps, grass tussocks, logs, rocks, river banks, termite mounds, and mammal burrows (Grobler 1982; Hailey and Coulson 1995; Boycott and Bourquin 2000; McMaster and Downs 2006).

Plant species known to be eaten by leopard tortoises must grow in adequate variety and abundance in the release areas (Ashton and Ashton 2009). Leopard tortoises are regarded as intermediate between generalist and specialist feeders, and are known to eat a variety of plants and fruits, including grasses (e.g. *Cynodon dacytlon*) and succulents (e.g. *Crassula* sp.) (Mason et al. 1999; Boycott and Bourquin 2000). The full diet of *S. p. pardalis* in KwaZulu-Natal is unknown as this has not been studied. However, a number of species of plants indigenous to KwaZulu-Natal are known to be eaten by leopard tortoises (Branch and Braack 1987; Broadley 1989; Boycott and Bourquin 2000; Rall, unpubl. data; P. Goodman, Ezemvelo KZN Wildlife, pers. comm.). At the release site, leopard tortoises should be able to access water, as they drink from open water sources (e.g. puddles), but are said to be able to survive long periods without drinking (Grobler 1982; Rall 1985; Bourquin 1990; Boycott and Bourquin 2000).

The release program should be fully understood, accepted and supported by the neighboring landowners and local communities. Protection of the tortoise population must be assured, by ensuring that the release sites have the infrastructure to prevent wildlife poaching and interference by humans. Release areas had to be on private land in KwaZulu-Natal, as release is not permitted in state protected areas.

Study Sites. — After consideration of the aforementioned criteria, two release sites were chosen. In January 2005, 22 *S. p. babcocki* were released into the 913 ha Leopard Mountain Game Reserve (27^{o}48’S, 32^{o}12’E). In December 2006 and February 2007, 7 *S. p. babcocki* were released into the 2196 ha Usuthu Gorge Community Conservation Area (26^{o}52’S, 32^{o}06’E). Leopard Mountain GR had been in existence for 8 years before the release. The land use of some of the neighboring areas had changed from cattle farming to wildlife conservation at least two years before, and all these areas were joining up to form a much larger protected area. Usuthu Gorge CCA was a newly established protected area at the time of the initial release there.

The vegetation at Leopard Mountain GR is characterized as Zululand Lowveld, occurring between 50 - 450 m altitude, mainly on flat or slight undulating landscapes in a summer rainfall area (500 - 900 mm) (Mucina and Rutherford 2006). The reserve is covered by woodland, thicket, bushland, and wooded grassland, which are all suitable habitats for leopard tortoises. Some of the leopard tortoise's preferred food plants occur widely on the reserve, refuge sites are present, and water is generally accessible to these tortoises as it is present in various areas of the reserve (C. Viviers, landowner, pers. comm.). The vegetation at Usuthu Gorge CCA is characterized as Southern Lebombo Bushveld, occurring between 100 - 600 m altitude, on more undulating landscapes, including gorges and ridges, also in a summer rainfall area (550 - 1000 mm) (Mucina and Rutherford 2006). Some of the known food plants, as well as refuge sites and permanent water were present. We did not have the resources to undertake a survey of *S. p. babcocki* present on the release areas, or to perform quantitative habitat and food plant analyses (as suggested by Ashton and Ashton 2008, 2009). However, since both reserves had *S. p. babcocki*, and the reserves were within the historical range of the species (Bourquin 2004; Branch 1998), the other ecological requirements should be met.

The number of tortoises in the reserves was unknown but thought to be below carrying capacity, due to a recent severe drought in the region and having recently been converted from cattle farms to wildlife conservation areas (some areas neighboring Leopard Mountain GR), and being a recently formed nature reserve (Usuthu Gorge CCA). Tortoise shells were found on Leopard Mountain GR during the drought, but it is not known whether the tortoises succumbed to the drought (severe droughts often kill leopard tortoises; Van Zyl 1966) or to other factors such as fire (another known cause of mortality;

Boycott and Bourquin 2000). Before becoming wildlife reserves, there may have been high tortoise mortalities on the release areas and surrounding land because of the use of tortoises in traditional medicine (Cunningham and Zondi 1991) and for food, and from being burnt during uncontrolled fires or during fires designed to promote livestock production as opposed to wildlife conservation (Boycott and Bourquin 2000). As tortoises are killed by vehicles while crossing roads (Boycott and Bourquin 2000), it was important that neither release areas had tarred roads (which promote greater traffic flow and higher traffic speeds), and only Leopard Mountain GR had a district road passing through it, which was used mainly by reserve vehicles and vehicles of tourist clients entering or exiting the reserve.

Because we expected the numbers of *S. p. babcocki* to be below carrying capacity on the release areas, and owing to the fact that they are not territorial with overlapping home ranges (5-90%, average 24% for telemetered tortoises; McMaster 2001), and because of the small number released, we did not think that much social disruption in the resident population would result from the release, as indicated in a tortoise relocation study (Berry 1986).

Release. — On the release days, the tortoises were transported in crates to the reserves early in the morning, to minimize heat stress, and hard-released at one or more pre-determined sites in each reserve. At Leopard Mountain GR, the group of 22 tortoises (including 10 with radio-telemeters) was divided and released at two different sites, about 2 km apart. At Usuthu Gorge CCA, the tortoises were released at the same site, but tortoises T1 - T5 were released in December 2006, and T6 and T7 in February 2007. Tortoises were released in summer, as this is when there would be the most food available for them, compared with winter, and so no supplementary feeding was provided.

Post-release Interventions. — For the purposes of the study, we accepted that some of the *S. p. babcocki* might try to disperse from the release areas, but such dispersal was accommodated by the likelihood that the existing populations in the surrounding areas were below carrying capacity. However, we decided to return those tortoises that we detected as having moved from the fenced reserves because we wanted to ensure that we could relocate the tortoises through the study and we did not want the tortoises to potentially be exposed to greater threats than might occur on the patrolled areas during the study. We realized that some of the tortoises might disperse again later, but we hoped that by returning them they might settle down in the release areas (as this has been done in some tortoise relocation studies, e.g. Belzer 1999; Tuberville et al. 2005), or else that by the end of the study the tortoises would be more familiar with the habitat of the region. Furthermore, if any of the released *S. p. babcocki* showed signs of disease, the tortoise was taken to a veterinarian to be treated.

Monitoring. — The radio-telemetered tortoises released at Leopard Mountain GR were located monthly for the first 10 months after release, and sporadically (maximum 5 times) up to 25 months after release. The radio-telemetered wild tortoise was located monthly (after affixing the radio-telemeter), until the telemeter was found detached on the ground. Due to malfunctioning of some of the radio-telemetry equipment, not all radio-telemetered tortoises were found at each monitoring session. Non-telemetered tortoises were located opportunistically. Tortoises released at Usuthu Gorge CCA were located monthly for up to 13 months, when the study ended.

A 3-tier Yagi aerial and a wide-range receiver (Alinco, DJ-X10) were used to locate the radio-telemetered tortoises. Once found, their locations were obtained using a Global Positioning System (GPS; Garmin 12XL), the microhabitat and their activity noted, and the tortoises suspended in a bag and weighed using a scale (0.5 kg accuracy, Leopard

Mountain GR) and a spring balance (0.1 kg accuracy, Usuthu Gorge CCA). General health was also noted. The GPS locations were exported into the Geographical Information System (GIS) ArcMap 9.2 (Environmental Systems Research Institute Inc., Redlands, California) for further analyses.

Data Analyses. — The minimum convex polygons (MCP) encompassing the recorded locations for each tortoise were estimated using Hawth's Analysis Tools extension (Beyer 2004) for ArcMap. We recognize that the tortoises had probably not yet developed a home range during the study periods, and standard home range analyses might not be biologically significant or appropriate (Field et al. 2007), but we considered that these MCPs would be informative as indices of the areas covered by the tortoises after release.

To determine movement of each tortoise, the distance function in ArcMap was used to measure the minimum straight-line distance travelled each month ("minimum monthly movement"). If a tortoise left the reserve and was brought back, the distance measured for the next month was from that new location, not from where the tortoise was found outside the reserve. Minimum total distance travelled by each tortoise was the sum of these minimum monthly straight-line distances.

Changes in body mass were calculated as the difference between initial and final mass and expressed as a percentage.

RESULTS

Survival and Changes in Mass. — After 25 months of post-release monitoring at Leopard Mountain GR, there was only one tortoise confirmed to be alive (10%), three confirmed deaths (30%), and six whose fate was unknown (Table 1). Tortoise L6 was found injured 2 months after release, with a hole in its carapace likely caused by a pick-axe or similar sharp instrument, and with the radio-telemeter detached. It subsequently died. Tortoise L10 was driven over and killed by a vehicle 10 months after release, and tortoise L2 was found dead 17 months after release, lying on its side, wedged against a shrub (Table 2). In addition, one non-telemetered released tortoise was found driven over and killed 3 months after release. The radio-telemeter from tortoise LW was found detached but still functioning on the ground 21 months after it was attached, and no further sighting of the tortoise was made. Due to known failure of two radio-telemeters (on L4 and L7), it was the likely cause of the disappearance of the other tortoises.

After 13 months of post-release monitoring at Usuthu Gorge CCA, there were only three out of seven tortoises alive, namely T1, T4, and T5. However, T5 was listed as “dead” in terms of the study, as it was taken back to CROW four months after being released, because it had mucus bubbling from its nares, loose skin, sunken eyes, was losing weight (Table 2), and did not move far each month (see below). The cause of its illness was undetermined. Other than T4 being taken out to be treated for extensive skin sloughing on its front legs, diagnosed as “non-contagious dermatitis caused by a hypersensitivity response” (R. Last, VetDiagnostix, pers. comm.), both T1 and T4 were healthy and had an accumulative weight gain of over 20% (Table 2). However, they could not be located 14 months after release.

The first tortoise to die at Usuthu Gorge CCA was T7, four months after being released. It was found freshly decapitated and with a laceration on one of its back legs. The edges of the wound were sharp and straight, which suggested that a person using a knife killed it (J. Vorster, Vetdiagnostix, pers. comm.). This tortoise was the only other one in this release (besides T1 and T4 mentioned above) that had gained body mass (Table 2). The second tortoise (T6) died 6 months after release, having lost 17% of its body mass

(Table 2). It was too decomposed for an autopsy, but visual inspection showed no visible marks on the carapace. It had behaved differently from most other tortoises, except T3, by always being in the open (not in a refuge) during autumn and winter. T3 was taken out of the reserve 9 months after release, as it had continued to lose body mass since May, was found with loose skin and sunken eyes and only retracted its limbs when touched. T3 had the largest body mass loss of all the released tortoises (Table 2). It was brought to a relatively large, secured garden outside of the reserve, fed, given water and allowed to rest. Because it ate and drank it was decided not to take it back to CROW and it was left to recuperate. Unfortunately it died a few days later and no autopsy was performed. The last known death was of T2, whose body mass had decreased (Table 2) before it was found dead, lying on its back, 10 months after release. A post-mortem was not done because it was too decomposed when found. There were no visible injuries on its carapace.

Minimum Straight-Line Distances. — At Leopard Mountain GR, most of the tortoises' first large recorded movements from the release points were either in a northeasterly (n = 4) or southwesterly direction (n = 3), while a few others moved in a northwesterly (n = 2) or southeasterly direction (n = 1) (Fig. 1). Similarly, those released at Usuthu Gorge CCA had minimum straight-line distances in either a northeasterly direction from the release point (n = 5) or in a northwesterly direction (n = 2) (Fig. 2). At both reserves, most tortoises changed directions from this initial direction, which was pronounced in L2 (Fig. 1) and T3 (Fig. 2).

Several tortoises travelled outside each of the reserves after each release. At Usuthu Gorge CCA, both T4 and T7 travelled outside the reserve, in a similar direction, in December and April, respectively (Fig. 2). When T7 was brought back to the original release site, it went in a similar direction as it had done previously (T7b, Fig. 2), whereas T4 went roughly 180^{o} in the other direction compared to the direction it had originally taken (T4b, Fig. 2). T4 left the reserve again a month later and was retrieved and released (T4*, Fig. 2) near where T1 was last located. At Leopard Mountain GR, 3 months after release, L5 left the confines of the reserve. It was retrieved and released within the reserve boundary (Fig. 1), but by the next month had disappeared. Tortoise L10 had also left the confines of the reserve after 3 months (Fig. 1), but the boundary fence had been removed at this time and so it was not brought back to the reserve.

At both reserves, monthly recorded movements were variable between the tortoises and between months, but most tortoises travelled less than 400 m (minimum straight-line distance) each month. At Leopard Mountain GR, large movements (> 400 m minimum straight-line distance) were recorded in the first month after release (L5: 1419 m, L6: 891 m) and again in June (L3: 431 m, L8: 673 m), July (L10: 456 m), August (L2: 558 m), and November (L1: 434 m, L8: 567 m). The wild tortoise only exceeded 200 m (minimum straight-line distance) per month in spring (October). Conversely, all tortoises released at Usuthu Gorge CCA (except T5 as it was diseased and thus did not move further than 156 m each month), had recorded minimum straight-line movements larger than 900 m, either in the first month (T2: 928 m, T4: 1283 m), the second (T6: 1012 m), or the third month (T1: 1138 m) after release. Tortoise T3 had recorded minimum straight-line movements of 936, 1633, 990, and 976 m for the first four months after release, while tortoise T7 had values of 1428, 1115, and 1375 m for the first three months after release. In addition, there was a clear decrease in recorded minimum straight-line movements of tortoises released at Usuthu Gorge CCA in winter months (June - August), these being generally < 100 m per month, which was not seen as distinctly in the tortoises released at Leopard Mountain GR. Following winter, both tortoises T2 and T4 showed an increase in recorded minimum straight-line movements from September onwards, but T4 especially travelled far each month, attaining a recorded minimum straight-line movement of over 2000 m in January 2008.

Excluding T5, average monthly minimum straight-line distance for tortoises at Usuthu Gorge CCA ranged from 132 to 1045 m, total minimum straight-line distance travelled ranged from 1092 to 6144 m and total MCP area ranged from 3.1 to 150.5 ha (Table 3). At Leopard Mountain GR, excluding L5, L6, and L7 due to small sample size, average monthly minimum straight-line distance ranged from 83 to 283 m, total minimum straight-line distance travelled ranged from 650 to 1801 m and total MCP area ranged from 4.6 to 48.4 ha (Table 3). The wild tortoise had the second lowest average monthly minimum straight-line distance and MCP area (Table 3). The maximum "minimum straight-line distance" from the release site for tortoises released at Usuthu Gorge CCA (excluding T5) ranged from 922 to 2585 m, while that at Leopard Mountain GR (excluding L5, L6, and L7) tended to be less (449 to 1612 m; Table 3).

DISCUSSION

The results from both the Leopard Mountain GR and Usuthu Gorge CCA releases indicated the large individual variation in the response (i.e. minimum distances moved and recorded directions taken) by rehabilitated *S. p. babcocki* when released into the wild. These tortoises dispersed in various directions from the release site, monthly minimum straight-line distances varied from < 100 m to > 2000 m and they covered MCP areas ranging between 1.4 ha and 150.5 ha in size. Individual variation in response to release has been seen in tortoise relocation studies, such as in the time taken to leave the vicinity of the release site and propensity for and duration of long distance dispersions (Belzer 1999; Cook 2004; Tuberville et al. 2005; Hester et al. 2008). Wild leopard tortoises are also highly variable in daily distance travelled and in home range, such that one male would have a home range of 12.6 ha and another male a home range of 229.0 ha in the same season (McMaster and Downs 2009). However, a possible reason for the larger MCP areas covered by tortoises at Usuthu Gorge CCA compared with those at Leopard Mountain GR may be in response to food resources being scarcer or more scattered (Mazzotti et al. 2002; McMaster and Downs 2009). However, these areas cannot be considered home ranges, since a year seems to be required for the development of a home range for species such as the ploughshare (*Astrochelys yniphora*; Pedrono and Sarovy 2000), gopher (Tuberville et al. 2005) and desert tortoises (Field et al. 2007), and box turtles (Cook 2004). It may even take longer for tortoises that do not show site fidelity.

Released tortoises that make long-distance uni-directional movements away from the release site have been termed “dispersers” (Tuberville et al. 2005). These dispersers, 25% of released box turtles (Cook 2004) and 42% of total released gopher tortoises in three different penning treatments (Tuberville et al. 2005), often ended up leaving the confines of the study site. These tortoises were retrieved and often had to be re-released several times before they settled near the release site (Belzer 1999; Tuberville et al. 2005). One suggestion is that these animals are homing (Mathis and Moore 1988). However, other studies on relocated tortoises and terrapins have shown that they are only able to home if the release site is close to the original capture site, otherwise they cannot pick up on odors or visual land marks to guide them (Able 1980; Hester et al. 2008). It has been suggested that some tortoises and terrapins cannot home as effectively as others because they do not have life histories that require the evolution of complex orientation systems (Caldwell and Nams 2006). With regards to the present study, leopard tortoises have homing abilities, as one individual was recorded to have returned to its original capture site about 12 km away after translocation (Bertram 1979). However, owing to the rehabilitated tortoises in our study being released further than 600 km away from the rehabilitation center, homing back there would seem unlikely. Furthermore, those individuals that were retrieved did not always travel in the same direction as taken previously (e.g. T4 in our study), as expected with homing (Belzer 1999). Individuals that home are not necessarily those that disperse far from the release site (Cook 2004). It is more likely that some individuals (e.g. L5, T4, and T7 in our study) are predisposed to disperse (Belzer 1999; Cook 2004; Tuberville et al. 2005), termed “transients” (Kiester et al. 1982, Belzer 1999). However, another reason for individuals to disperse is to find suitable habitat (Caldwell and Nams 2006). Dispersal after release is the most common cause of failure of reptile translocations (Germano and Bischop 2008), owing to increases in mortality from large energy expenditure before adequate food resources are found, and because of the increased chance of encountering predators and accidental death (Hester et al. 2008). Dispersal, together with pneumonia, was seen as the main factor affecting survival of released box turtles (Cook 2004).

To judge whether a release is a success, based on survival, the known mortality rate for wild individuals needs to be taken into account (Molony et al. 2006). Annual survival for wild leopard tortoises has been estimated as 80% for males and 72% for females (Hailey and Coulson 1999). Therefore having only 29% of tortoises survive one year at Usuthu Gorge CCA and 10% known to have survived two years at Leopard Mountain GR indicate that these releases were failures. In addition, the causes of death are further indicators of failure, as in this study at least three deaths (L6, L10, T7) were human-induced and at least four deaths (T2, T3, T5, T6) were due to the inability to adapt to release and/or to disease.

Human-induced deaths were assumed for both L6 and T7 in accordance with the pathology reports. In addition, since T7 was found with an intact shell, predation by natural predators is unlikely (Peterson 1994; Hill 1999; Coulson and Hailey 2001), while decapitation suggests use in indigenous medicine, as the tortoise neck is said to have special powers (Cunningham and Zondi 1991). The vehicle-induced deaths of L10 and a marked tortoise with no telemeter attached appear to be unusual for a protected reserve, but deaths caused by vehicles have occurred in other tortoise releases (e.g. Cook 2004; Danielski 2008; Hester et al. 2008) and in wild leopard tortoise populations (Douglas and Rall 2006). A more natural cause of death, namely disease (indicated by nasal discharges), has been suspected in some tortoise relocation projects (Cook 2004; Field et al. 2007). Disease, or possibly the inability to adapt to the release, may be the cause of the death of three tortoises at Usuthu Gorge CCA. The largest (T3) and smallest (T6) tortoises may have died from dehydration (Berry et al. 2002) and/or disease (Oettle et al. 1990), because their symptoms were similar to those of other tortoises suffering these conditions, such as the lack of refuge-seeking in autumn and winter (Oettle et al. 1990). Also, T3 may have lost energy by covering large distances for several months after release, possibly searching for forage in an unfamiliar area (Hester et al. 2008), or maybe being too old to settle (Pedrono and Sarovy 2000). Both tortoises may not have known which food was the most nutritionally beneficial (Bright and Morris 1994), perhaps as a result of too long a period spent in captivity. The release site could have been significantly beyond its region of origin, and thus supporting a different vegetation type to which the tortoise was adapted. As suggested by a loss in body mass and condition since release, in addition to having no visible injuries to its carapace, tortoise T2 may also have died from dehydration, starvation and/or disease, and then been turned over by a scavenger (Peterson 1994). Another possible explanation is that another leopard tortoise or animal may have pushed it over. Scuff marks on the ground are suggestive of this cause in the case of L2. Since both were females that died within the mating season (September to April), a male may have been too forceful in his attempts at copulation, where courtship involves continuously barging into the back and sides of the female (Boycott and Bourquin 2000).

A concern for future rehabilitated, or captive, leopard tortoise releases is the emergence of disease in the released tortoises (e.g. T5) and the potential pathogen transfer that could take place to an otherwise naturally healthy wild population. Disease is the main reason (besides genetic pollution) for the IUCN not being in favor of placing confiscated animals back into the wild (IUCN 2000). This view is supported by a document developed to guide decisions on whether to release captive tortoises (e.g. from rehabilitation centers) into the wild (Jacobson et al. 1999). Therefore, rehabilitated tortoises for future releases must have thorough health checks, preferably by a veterinarian, such as those suggested by Jacobson et al. (1999) and Berry and Christopher (2001), and should include hematological tests (Dodd and Siegel 1991) and fecal sample and nasal flush analyses (Klemens 1995). However, vulnerability to infections carried by ticks or mites at the release site by parasite-free *S. p. babcocki* needs to be further studied (Viggers et al. 1993; W.R. Branch, herpetologist, pers. comm.).

Even though 47% of the *S. p. babcocki* released in this study died, at least 5 (29%) of the released tortoises were known to have survived 13 months post-release and were in good health. Some even had a greater increase in body mass (> 20%) than successfully released ploughshare tortoises (Pedrono and Sarovy 2000). Therefore it does seem possible to successfully release rehabilitated *S. p. babcocki*, after several improvements are made to the release protocol as suggested below.

Management Implications. — To allow for rehabilitated *S. p. babcocki* to become accustomed to the diseases present at the release site, or for diseases to reveal themselves, they could be placed in an enclosure for a period before release (Dodd and Siegel 1991). This may also help to increase site fidelity (Pedrono and Sarovy 2000; Tuberville et al.

2005; Ashton and Ashton 2008), and to allow them to adapt to eating the indigenous vegetation in the area. Penning the animals for 12 months before release has significantly increased site fidelity in one study on gopher tortoises, where only one out of 12 dispersed, compared with no-penning (10 dispersing out of 13) and penning for 9 months (5 dispersing out of 13) (Tuberville et al. 2005). Therefore, it would be useful to examine the effects of penning in future releases of rehabilitated *S. p. babcocki*. However, since some of the penned gopher tortoises did disperse and had to be retrieved, and three tortoises dispersed again in the second year following release (Tuberville et al. 2005), penning is not a foolproof solution in ensuring site fidelity. Furthermore, this intervention is likely for rehabilitated *S. p. babcocki* to be impractical, due to costs in relation to the conservation status of this species (Boycott and Bourquin 2000). Therefore, less expensive and less time-consuming options could be attempted in future releases, such as ensuring the release area is large enough to accommodate the tortoises' ability to disperse. Calculations have been made of the reserve sizes needed to accommodate released gopher tortoises (Berry 1986) and box turtles (Cook 2004). Using the method outlined by Cook (2004), the required reserve size for future rehabilitated *S. p. babcocki* releases would need to be approximately 2099 ha. This size is actually less than the Usuthu Gorge CCA where tortoises were released, and thus other preventative measures are suggested. These include ensuring the reserve fencing is properly secured to prevent tortoises from pushing through, and releasing tortoises at a suitable site in the middle of the reserve to decrease the possibility of them encountering the boundary. Rehabilitated *S. p. babcocki* should also be released in less undulating landscapes than Usuthu Gorge CCA, as even though some wild leopard tortoises were seen there, rehabilitated tortoises might not be as fit as wild tortoises due to their time in captivity, as found in a study on rehabilitated raptors (Curtis and Jenkins 2002). In addition, the quality and quantity of food available in the habitat needs to be assessed (Ashton and Ashton 2008, 2009). Future releases should be at the start of spring, just after the first rains, when tortoises generally become more active (Boycott and Bourquin 2000), so that they have more time to build up energy reserves before winter, than if released later. Lastly, future post-release monitoring could be carried out by the local residents (e.g. game rangers), because having local people involved in tracking has been shown to decrease the interest in harvesting tortoises in Egypt (Attum et al. 2008).

To assess whether these suggestions are beneficial, future releases of rehabilitated leopard tortoises should be in accordance with an amended release protocol that includes long-term post-release monitoring. Otherwise, one has to accept that animal welfare will be compromised, because there will be mortality that is human-induced or due to disease or due to inability of the tortoises to adapt to the environment and habitat of the release area. The alternative of keeping these tortoises in captivity should not be a standard option, due to the large space requirements of the leopard tortoise, which normally cannot be supplied in captivity. Generally allowing the keeping of leopard tortoises in captivity is likely to stimulate the desire of other people to obtain leopard tortoises as pets. In both these respects, captivity may have negative welfare implications, such as the acquisition of shell deformities owing to poor diet, and injuries received from vehicles, lawnmowers, dogs, etc., all of which have been noted on tortoises at CROW in Durban. An imperative is that extensive public education is carried out to dissuade the public from illegally keeping tortoises as pets. Otherwise the option of euthanasia may need to be considered.

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Table 1. Pre-release measurements of each *S. p. babcocki* released in January 2005 at Leopard Mountain Game Reserve, and their status at the end of the study or when they became undetectable or until their demise (duration after release specified under column N). Note that initial weights were measured between 1 and 5 months after release.

Tortoise	Sex	Straight carapace length (mm)	Carapace height (mm)	Initial weight (kg)	No. months	Status
L1	F	263	120	3.5	17	Unknown
L2	F	264	143	2.5	17	Dead
L3	F	287	145	3.5	10	Unknown
L4	M	271	120	3.0	6	Unknown
L5	M	275	137	3.0	2	Unknown
L6	F	276	136	3.5	2	Dead
L7	F	424	212	6.0	1	Unknown
L8	M	270	127	3.0	10	Unknown
L9	M	310	137	4.0	25	Alive
L10	M	313	140	4.5	10	Dead
LW	F	n/a	n/a	6.3	21	Unknown

Table 2. Pre-release measurements of each *S. p. babcocki* released in December 2006 (T1-T5) and February 2007 (T6, T7) at Usuthu Gorge Community Conservation Area, as well as percentage mass body change between initial and final measurements and their status at the end of the study (duration after release specified under column N). Note that initial weights were measured before release.

Tortoise	Sex	Straight carapace length (mm)	Carapace height (mm)	Initial weight (kg)	Body mass change (%)	No. months	Status
T1	F	309	161	4.3	+ 26%	13	Alive
T2	F	227	119	2.8	– 11%	10	Dead
T3	F	463	211	15.3	– 33%	9	Dead
T4	M	328	170	5.0	+ 24%	13	Alive
T5	M	255	126	3.0	– 7%	4	Removed
T6	F	181	99	1.2	– 17%	6	Dead
T7	F	290	162	4.4	+ 15%	4	Dead

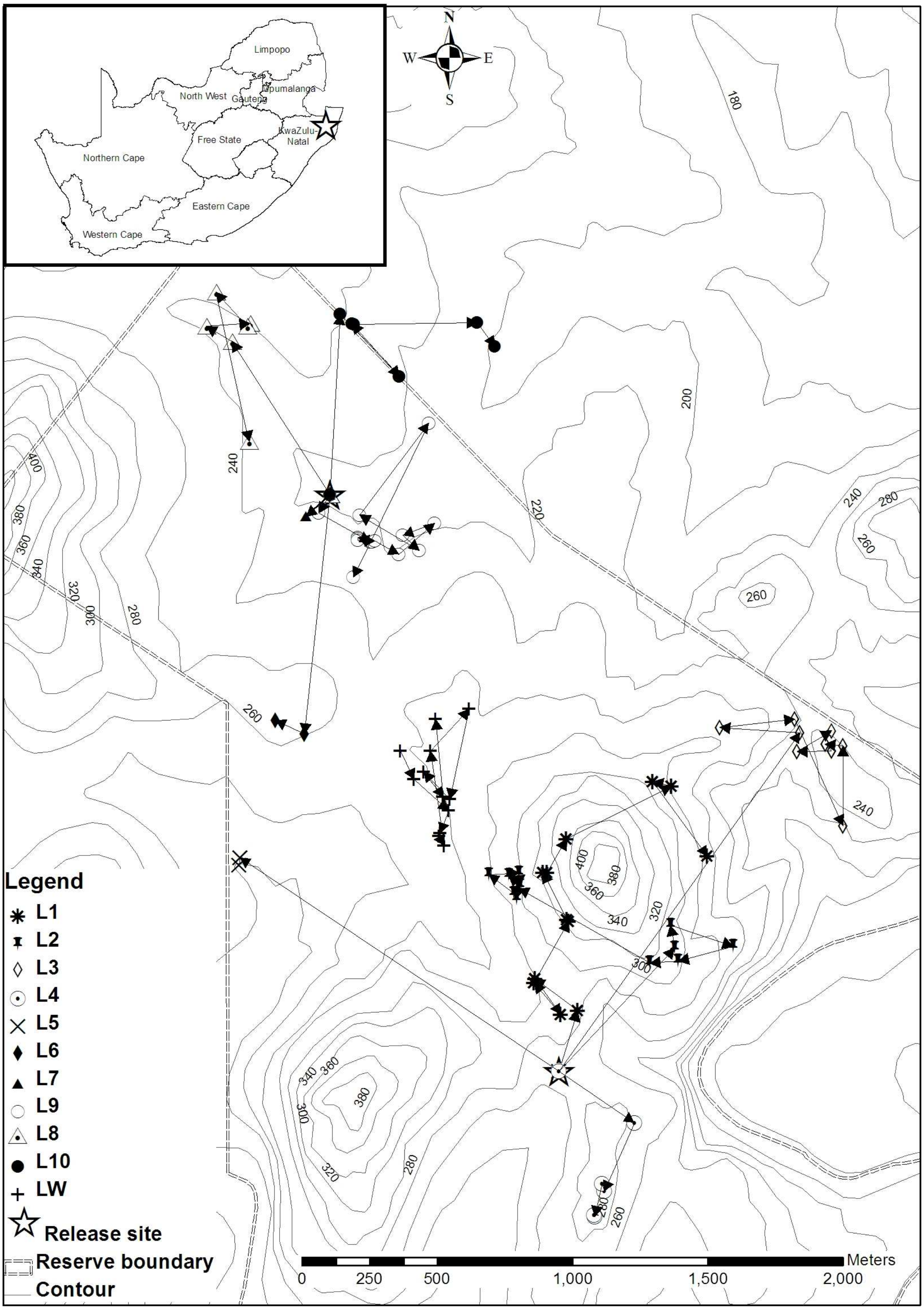
Table 3. Total and monthly (average ± SE) minimum straight-line distances travelled, maximum straight-line distance travelled from release site, and estimated area covered (MCP) as recorded for *Stigmochelys pardalis babcocki* up to 10 months after release (November 2005) at Leopard Mountain Game Reserve, and for *S. p. babcocki* released at Usuthu Gorge Community Conservation Area, before their demise, disappearance, or the end of the study. The number of months used in calculations is specified.

Site	Tortoise	Duration (months)	Total (m)	Monthly average (m)	Maximum from release site (m)	Area (ha)
Leopard Mountain Game Reserve	L1	Jan-Nov (10)	1801	180.2 ± 38.5	1133	22.3
	L2	Mar-Nov (8)	1378	172.3 ± 61.5	793	29.8
	L3	Mar-Nov (8)	1684	210.0 ± 48.2	1612	48.4
	L4	Jan-Jul (4)	650	162.6 ± 84.7	553	6.3
	L5	Jan-Mar (2)	1446	N/a	1419	N/a
	L6	Jan-Mar (2)	1010	N/a	891	N/a
	L7	Jan-Feb (1)	120	N/a	120	N/a
	L8	May-Nov (6)	1698	283.0 ± 109.8	860	11.1
	L9	Jan-Nov (10)	832	83.3 ± 23.1	449	4.6
	L10	Mar-Jul (4)	1041	260.5 ± 94.3	836	16.9
	LW	Apr- Nov (8)	1136	142.1 ± 38.1	n/a	5.8
Usuthu Gorge Community Conservation Area	T1	Dec-Jan07 (13)	3076	235.6 ± 89.2	2047	69.5
	T2	Dec-Oct (10)	1319	132.0 ± 89.4	954	3.90
	T3	Dec-Sep (9)	4642	515.9 ± 207.1	922	70.3
	T4	Dec-Sept, Nov-Jan07 (12)	6144	512.1 ± 188.5	2585	150.5
	T5	Dec-April (4)	340	85.1 ± 24.9	217	1.4
	T6	Feb-Aug (6)	1092	182.1 ± 166.0	1025	3.1
	T7	Feb-June (4)	4180	1045.1 ± 269.6	1849	87.5

Figure legends

Figure 1. Leopard Mountain Game Reserve study site in KwaZulu-Natal province, South Africa, showing monthly minimum straight-line movements (arrows indicate directions) of all *Stigmochelys pardalis babcocki* (L1 to L10) up to 10 months after release, as well as movements of a wild *S. p. babcocki* (LW).

Figure 2. Usuthu Gorge Community Conservation Area study site in KwaZulu-Natal province, South Africa, showing monthly minimum straight-line movements (arrows indicate directions) of all *Stigmochelys pardalis babcocki* (T1 to T7) up to 13 months after release. Note that the direction taken after T4 was re-released at the release point is marked with "T4b", while the second release point (see text) is marked with "T4*". The direction taken by T7 after being re-released is marked with "T7b".



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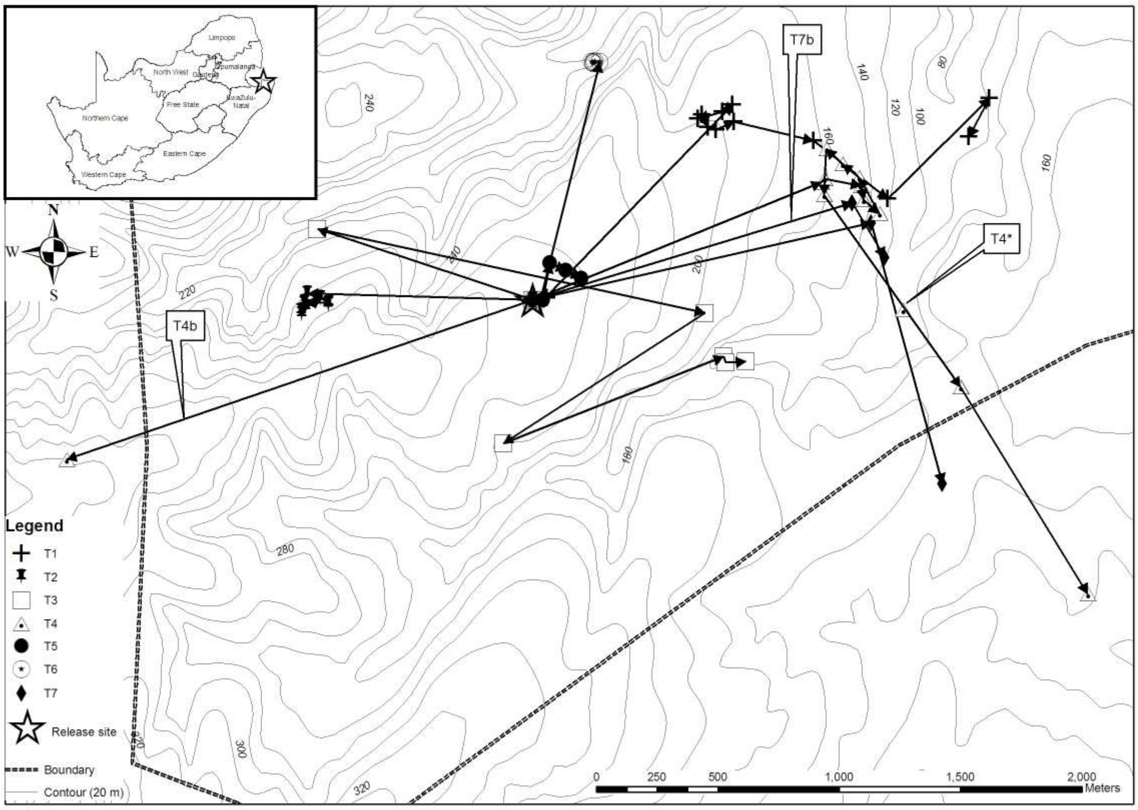

Figure 2. Usuthu Gorge Community Conservation Area study site in KwaZulu-Natal province, South Africa, showing monthly minimum straight-line movements (arrows indicate directions) of all *Stigmochelys pardalis babcocki* (T1 to T7) up to 13 months after release. Note that the direction taken after T4 was re-released at the release point is marked with "T4b", while the second release point (see text) is marked with "T4*". The direction taken by T7 after being re-released is marked with "T7b".

CHAPTER 6

Two unsuccessful re-introduction attempts of rock hyrax (*Procavia capensis*) into a reserve in the KwaZulu-Natal Province, South Africa

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Rock hyrax (*Procavia capensis*) are categorised as “least concern” in the 2008 IUCN Red List of Threatened Species. In South Africa they were once listed as vermin in the old Cape province due to their high population numbers and impact on grazing. However, about 10 years ago, populations in the KwaZulu-Natal province became locally extinct. This resulted in the recent re-introductions of rock hyrax, purchased at annual wildlife auctions in the province. Success of these re-introductions was unknown as there had been no post-release monitoring. This study determined the success of re-introducing rock hyrax, using two source populations, namely rock hyrax that had been in captivity for 16 months (n=17) and those from the wild (n=9). Captive rock hyrax did not have site fidelity after release and after three months could not be found. All wild rock hyrax, except one whose fate is unknown, were found dead within 18 days. One had an accidental death while the rest were preyed upon. In conclusion, the reintroduction of captive and wild rock hyrax likely failed due to predation. This may have been a consequence of group disintegration, probably as a result of incorrect group composition, captive stress, and type of release. Suggestions to improve the success of future rock hyrax re-introductions are provided.

Key words: KwaZulu-Natal, rock hyrax, *Procavia capensis*, re-introduction, post-release monitoring, failure.

INTRODUCTION

Rock hyrax (*Procavia capensis*) have a wide distributional range throughout Africa, being limited mainly by the presence of suitable rocky outcrops (Skinner & Chimimba 2005). They live in colonies of up to 36 individuals, largely consisting of a harem of females and a territorial male (Fourie & Perrin 1987a). Even though they have an eight month gestation and usually give birth to one or two young (Miller 1971), their numbers have in the past increased to such a degree that they have officially been listed as vermin in some areas in South Africa (Hey 1964; Kolbe 1967; Lensing 1978). Explanations for the population growth include eradication of the natural predators (Kolbe 1967), but the problem was over-exaggerated due to conflicts with grazing for commercial farming (Lensing 1978). Rock hyrax are categorised as “least concern” in the 2008 IUCN Red List of Threatened Species (IUCN 2008). However, their numbers have declined due to disease, predation, territorial fighting and dispersal of males (Hoeck *et al.* 1982). They are killed by a variety of predators, including Verreauxs’ eagle (*Aquila verreauxii*), and are especially vulnerable to predation when they disperse, leading to a high male, especially juvenile, mortality (Hoeck 1982). Whole populations have become locally extinct due to drought (Barry & Mundy 1998), but mainly because of disease. Sarcoptic mange has resulted in the extirpation of rock hyrax in 1974 in Tanzania (Hoeck 1989) and in 1998 in Zimbabwe (Chiweshe 2005). This disease may have caused their localised extinctions in the KwaZulu-Natal province (KZN), South Africa, 10 years ago, but speculations exist that the cause was viral (I. Rushworth & K. Gordon Ezemvelo KZN Wildlife pers. comm.)

Since 2004, rock hyrax purchased from the local conservation authority's (EKZNW) wildlife auctions have been reintroduced into various areas of KZN e.g. Escourt, and Weenen (R. Devduth EKZNW pers. comm.). However, no post-release monitoring was done to assess their success. In Gauteng province, South Africa, rock hyrax are removed from overpopulated urban nature reserves and released into areas where rock hyrax numbers have thought to have declined, with the additional benefit of ensuring the survival of Roodekrans Verreauxs' eagle populations ("Hyrax Operation Project": B. van der Lecq Endangered Wildlife Trust pers.comm). Limited post-release observations suggest that only three out of six reintroductions resulted in self-sustaining populations (B. van der Lecq pers.comm.). There have been three published accounts of rock hyrax translocations, but post-release monitoring was limited. In the Eastern Cape province, South Africa, 22 rock hyrax (18 females, four males) were captured and translocated to a holding site before being released (in four batches) at a site roughly 1km away from the capture site (Crawford & Fairall 1984). Some were known to have survived for a few months after release, with two males returning to the vicinity of the capture site, but exact details were not given (Crawford & Fairall 1984). In the Serengeti, Tanzania, rock hyrax have been re-introduced onto rocky outcrops using six individuals (four females, two males), which grew to 20 over five years (Hoeck 1982) and a pair (male, female), which grew to 15 over 10 years (Hoeck 1989), but further details were not documented. The present study was instigated to provide further insight into the fate of translocated/re-introduced rock hyrax, through post-release monitoring. Success of release was assessed in terms of a reintroduction, such that the objective was to have a self-sustaining population of released animals (IUCN 1998).

MATERIALS AND METHODS

There were two source populations for the re-introductions: rock hyrax kept in captivity for 16 months (i.e. “captive”) and wild rock hyrax. The IUCN’s Guidelines for Re-introductions (1998) were partly followed, in that relevant biological information was gathered from the literature so that the re-introduction procedure considered the habitat and social and food requirements of this species. It was impossible to determine what caused the decline in the population, as it was reported to have occurred 10 years ago and no data was collected (I. Rushworth EKZNW pers. comm.). Ethical clearance was obtained from the University of KwaZulu-Natal (UKZN) ethics committee, and the relevant permits for capture, transport, holding in captivity and release of rock hyrax were granted by the provincial government.

Release site

The release site was the 656 ha Umgeni Valley Nature Reserve **(**29^{o} 28’S, 30^{o} 16’E), near Howick, in KZN. Previously this reserve had naturally occurring rock hyrax, but experienced a drastic population decline 10 years previously (G. Boothway Umgeni Valley Nature Reserve pers.comm.). There were apparently two remnant groups of about four and five rock hyrax in the reserve (G. Boothway pers.comm.), but only four lone individuals were observed in the reserve during two years of the study (Wimberger pers. obs). The vegetation is characterised as Midlands Mistbelt Grassland, with KZN Hinterland Thornveld nearby (Mucina & Rutherford 2006). The release site within the reserve was selected on it meeting the perceived criteria of shelter (rock crevices) and food requirements of rock hyrax, which includes leaves from trees (e.g. *Celtis africana*) and succulents (e.g. Aloe sp.), and grasses (Fourie & Perrin 1989). Captive rock hyrax were released within an extensive cliff range (indicated by a white star shape, Fig. 1), while the wild rock hyrax were released on the slope of the valley, below the cliffs (indicated by a black star shape, Fig.1). Signs of previous occupation of rock hyrax were evident near both release sites but none were observed in the immediate vicinity on repeated visits to the area.

Capture site and general capture methods

Rock hyrax were caught from Ladysmith, KZN (28^{o} 30'S, 29^{o} 45'E), about 150 km away from the release site, because the rock hyrax there were abundant and viewed as pests. The capture site had a colony of rock hyrax, which may have included several family groups, as documented elsewhere (Gerlach & Hoek 2001). Mammal traps (900 x 310 x 320 mm), were baited with cabbage and set up at the chosen capture site at sunrise and monitored until about 10h00, then again at about 14h30 until sunset, as these are periods of peak hyrax activity (Hoeck 1975; Brown 2003). Once caught, a blanket was used to cover the cage, to minimise stress. The rock hyrax was then transferred into a securely closed basket (420 x 250 x 250 mm), with cabbage placed within, and was again covered with a blanket.

Captive rock hyrax

These rock hyrax were caught in winter (July 2005) when the scarcity of food made them easier to catch. Ten rock hyrax, six females and four males, were caught and housed at UKZN Animal House Facility, Pietermaritzburg, where they remained in captivity for 16 months for an unrelated research study. For that study, they were housed in four small groups, namely: two females, two females and one male, two females and two males, and one female on its own. They were provided with wooden shelves for climbing and each cage had a hay-filled asbestos hutch (670 x 480 x 690 mm). Three months into captivity (in October), eight rock hyrax (two females, six males) were born. Approximately one year after capture of the original ten rock hyrax, after their first health check (see below), they were housed together in an outdoor cage (5.9 x 2.5 x 3.2 m), again with wooden shelves for climbing and four hay-filled asbestos hutches. They were fed daily with fresh cabbage, apples, carrots and rabbit pellets (Epol, Johannesburg, SA) and water was provided *ad libitum*.

All rock hyrax underwent three months of intensive disease and health monitoring prior to their release in November 2006. Monitoring included monthly group faecal collection for analyses of parasitic worms and eggs. Once a month rock hyrax were taken to a veterinary clinic and each anaesthetised with 15-20 mg Zoletil 100 (Virbac Animal Health, Johannesburg, SA). During the first visit measurements of head-body length (distance from the tip of nose in a straight line to end of the tail (Fourie 1983)) was recorded for all. To allow for easy identification of the sexes, we marked each hyrax by attaching a coloured, plastic material (Sterkolite) onto both sides of the ear, while they were still anaesthetised. Each tag was numbered to allow for individual identification. Each month, body mass for all individuals was recorded, and individual skin scrapings for determination of mite presence, specifically the sarcoptic mange mite (*Sarcoptes scabei*) were obtained. Monthly individual blood samples (2-5ml of blood) were taken by a veterinarian and sent to the pathology laboratory (VetDiagnostix, Pietermaritzburg, SA) for haematology and biochemistry analyses. The values were compared to the reference range provided by the International Species Information System (ISIS 2002). In addition, each rock hyrax was sprayed with anti-flea/tick medication (Frontline, Fipronil, Merial, Halfway House, SA). At the last health check, all individuals were vaccinated against rabies.

By the time of release, three adult females and one pup (juvenile less than two months old (Barry 1994)) had died in captivity, caused by old age, suffocation from being in the incorrect position for a pregnant female to recover from anaesthetic, illness (Pasteurella pneumonia: Dr O. Tatham Hilton Veterinary Clinic pers. comm.), and accidental injury respectively. In addition, two pups were born a few days before release. The decision to anaesthetise pregnant females for testing, and to include pups in the release were made in consultation with the veterinarian, and were based on preventing additional stress that would be caused by postponing the release, such as an increased time in captivity and having to re-do the health checks at a later stage. Consequently 17 rock hyrax were released (three adult females, four adult males, two juvenile females, six juvenile males, and two pups). Individuals were termed juveniles when younger than 12 months, sub-adults between 13 and 24 months old, and adults if older than 24 months (Fourie & Perrin 1987a), even though there is discrepancy over these age groups, as reproductive maturity is reached at about 16 months in females and 28 months in males (Fourie & Perrin 1987b).

Captive rock hyrax were hard-released to mimic the methods used by the local conservation authority (R. Devduth EKZNW pers. comm.). They were released straight from the transport boxes into a hay-filled hutch. The hutch was left there for several months after the release. To help the hyrax habituate, cabbage was provided on the release day and irregularly for one week after release.

The released hyrax were monitored daily for the first week and then twice a week for the rest of the first month. This decreased to once a week for the second month, twice a month for the third month and once during the fourth and fifth months. Each monitoring day was from 15h30 to 18h30 and 06h00 to 09h00 the next day, during greatest hyrax activity (Hoeck 1975; Brown 2003). Monitoring protocol changed from observing the released hyrax at the release site, to additional observations at two new sites (after three and 13 days respectively). Eighteen days after release the monitoring protocol was again changed to walking two transects along the cliff edge and face (0.95 km and 0.61 km), where there was suitable hyrax habitat. Hyrax have been recorded to disperse between 0.25 and 0.50 km (Fourie & Perrin 1987a). Both transects were walked twice in one monitoring session. The following observations were made: number of individuals seen; their sex and age class (based on relative size); any deaths; and their location with respect to the release site, which was measured using a measuring wheel.

Differences in body mass between the three months of pre-release measurements were tested using Repeated Measured Analysis of Variance (RMANOVA), and if significant, the Scheffé post-hoc test was used (Statistica, Statsoft Inc. Tulsa, OK, USA). Maximum number of hyrax seen on each day was used to determine the minimum number of hyrax alive in the group on each day.

Wild rock hyrax

Rock hyrax were caught over eight days in October (2007) and brought to the release site. To increase site fidelity after release (Bright & Morris 1994), they were kept for 14 days in a metal weld-mesh holding cage (1850 x 1850 x 1850 mm), including a roof and floor, at the release site. Most (75%) of the roof was also covered with canvas to provide protection from sun and rain. Two hay-filled hutches were placed inside the cage for cover. Branches were provided for climbing. Food and water were provided daily, as described before. Two days after the last group of hyrax were released into the cage, all nine hyrax (seven females, two males) were caught for pre-release health checks and measurements at the veterinary clinic.

As before, rock hyrax were first anaesthetised and measured. Age was determined using Stevens asymptotic growth equations for body head/body length, hind foot length and body mass (Fairall 1980). Individual skin scrapings to determine mite presence were obtained, and each individual sprayed with anti-flea/tick medication. For identification individuals were marked with different coloured cable-ties (104 x 2.5 mm, Insulok, Hellermann Tyton, SA) in alternate ears. Individual radio-collars (C. Dearden, Pietermaritzburg, SA) were fitted to the hyrax, so that they could be located after release. Each collar had a radio-transmitter with a unique frequency (150 VHF range) and a 1/8 wavelength stainless-steel tracer wire antennae powered by a lithium 3.5V AA battery, sealed in flexible rubber coating (ColourGuard, Loctite, USA). Each transmitter was attached with belting material, covered with heat-shrink tubing to prevent chaffing. Width of collars was 8 mm, but length depended on the individual hyrax's neck circumference, which averaged 181.1 ± 4.5 mm. Hyrax H1 was too small (neck circumference of 160 mm) to have a radio-collar attached. Collars weighed on average 23.0 ± 0.7 g (SE), less than 4% of body weight (Cochran 1980). For ethical reasons, collars were stitched together using cotton (2 mm thickness) to allow for the collars to fall off after about a year. After recovery from the procedures, they were released seven days later. Supplementary food was provided for several days after release, until there was no evidence of use.

Monitoring was conducted daily for the first week after release and then every few days until the end of the project. Monitoring sessions alternated between morning (start at 7h30) and afternoon (start at 16h30) and lasted until each radio-collared hyrax was located. A 3-tier Yagi aerial and a wide-range receiver (DJ-X10, Alinco Inc., Japan) were used to locate individuals. Positions of each rock hyrax were recorded using a Global Positioning System (GPS) (Garmin 12XL). The GPS positions were exported into the Geographical Information System (GIS) ArcMap 9.2 (Environmental Systems Research Institute Inc., Redlands, CA, USA) for further analyses.

RESULTS

Captive rock hyrax

Head-body length and body mass (in the first month) of rock hyrax varied with age and sex: adult males (n = 4) were 481.3 ± 20.0 mm (mean ± SE) and 2975.0 ± 394.5 g, adult females (n = 5): 472.4 ± 15.1 mm and 2820.0 ± 287.1 g, juvenile males (n = 6): 403.5 ± 7.3 mm and 1550.0 ± 71.9 g, and juvenile females (n = 2): 412.5 ± 12.5 mm and 1550.0 ± 150.0 g. There was no significant difference in body mass between months (RMANOVA, $F_{(2, 32)}$=2.786, p=0.077) (first (2258.8 ± 204.4 g), second (2388.2 ± 178.8 g) and third month (2400.0 ± 171.9)).

Individuals' blood results (haemoglobin, red blood cell count, haematocrit, MCV, MCH, MCHC, platelets, leucocyte count, neutrophils, lymphocytes, monocytes, eosinophils, basophils, sodium, potassium, chloride, urea, creatine, alkaline phosphotase, alanine aminotranferase, conjugate bilirubin and total protein) were generally within the reference range (ISIS 2000) (Wimberger unpub. data), with no disease evident (Dr J. Hill, Vetdiagnostix, pers.comm).

A day after release, a maximum of 58% of the released rock hyrax was seen (Fig. 2). More males than females disappeared, and near the end only females were located (Fig. 2). The un-identifiable hyrax ("unknown") were those that moved too quick to be identified, or no ear tags were seen. The pups were last seen alive 17 days after release and two days later, one of them was found dead due to starvation (Dr R. Last VetDiagnostix pers. comm), i.e. the mother abandoned it, or she had been killed.

Four days after release, captive rock hyrax occupied various sites other than the release site (Table 1). These sites were along the cliff range. Only juvenile males were observed at Site 5. After 87 days after release, none of the captive hyrax were located.

Wild rock hyrax

Based on head-body length, hind foot length and body mass, the group consisted of the following age classes: one juvenile male (H1; 360 mm, 58 mm, 1000g), one sub-adult male (H4; 405 mm, 65 mm, 1800 g), two sub-adult females (H2, H7; 400.0 ± 10.0 mm, 65.0 ± 1.0 mm, 1900.0 ± 200 g; H7 pregnant), and five adult females (H3, H5, H6, H8, H9; 468.0 ± 9.0 mm, 66.0 ± 0.4mm, 3300.0 ± 126.5 g; all pregnant). Whilst in the holding cage the six pregnant females gave birth to four and three pups, four and six days apart respectively, after the pre-release measurements were taken. The first pups were found dead inside the cage, still inside their birth sacks, while the second group of pups were alive for one day before being found dead with some of their body parts eaten. Both events were likely due to capture or captivity stress, as documented elsewhere (Calvete *et al.*, 2005).

Once released, the hyrax were very skittish and were not easily seen. Often they could be located only to the nearest rock crevice. Except for the initial and brief time H4 and H7 remained close to each other, the group had split up and were not seen together. Nearly all released hyrax died within 18 days of release, with the first death two days following release (Table 2). Hyrax were found dead close to the release site, except H3. This hyrax dispersed a day after release and was found with no visible injuries, lying bloated in the river vegetation. Based on post-mortems on three hyrax and the remains found for others, hyrax H1, H2, H4, H5, H7 and H9 were probably predated by caracal (*Caracal caracal*) (Dr. O. Tatham pers.comm; Grobler 1981). Because only one bone was found of H6 the predator could not be confirmed, and so may have been taken by a caracal or by the resident crowned eagle (*Stephanoaetus coronatus*, Boshoff *et al.* 1994) that nested near to the release site. The fate of H1 and H8 (Table 2) were unknown, but it is suspected that one was killed, as an unidentified rock hyrax spine was found with the remains of H4. In summary, after 18 days there were 8 out of 9 confirmed deaths while the fate of one was unknown.

DISCUSSION

The re-introduction of rock hyrax was unsuccessful, as none of the hyrax were known to have survived. The failure of these releases was a result of predation and group disintegration, as documented in other studies (e.g. Banks *et al,* 2002; and Gusset *et al*. 2006, respectively). Lack of group cohesion was probably due to a combination of factors including incorrect group composition, capture and captive stress, and type of release. Only the type of release has been linked with group disintegration (Bright & Morris 1994; Gusset *et al*. 2006; Hunter *et al*. 2007), while the other two have been implicated in the failure of translocations (Sarrazin & Barbault 1996, Shier 2006; and Calvete *et al*. 2005, Teixeira *et al*. 2007, Dickens *et al*. 2009 respectively).

Populations of hyrax are regulated by parasites, predation, intra-specific competition, reproduction, immigration and dispersal (Hoeck 1982). A variety of predators eat them, including black-backed jackal, *Canis mesomelas,* serval, *Leptailurus serval,* and puff-adder, *Bitis arietans* (Hoeck 1982), but they are the predominant prey of the crowned eagle (25% - 53%, Boschoff *et al*. 1994), caracal, (55%, Grobler 1981; 22%, Palmer & Fairall 1988), and Verreauxs' eagle (98%, Gargett 1990). Fourie (1983) has been estimated that 11% (n = 2804) of the post-reproductive hyrax population (n = 24 553) in an area were eaten by caracal in one year, and 4% (n = 840) by Verreauxs' eagle over the same time period. In our study, there were at least seven individuals (78% of wild group, 27% of total) killed by caracal within 18 days, and we assumed a similar fate for individuals in the "captive" group, which were not radio-collared. Rock hyrax are vulnerable to predation when foraging away from cover (Druce *et al*. 2006) and so are vulnerable when they are dispersing (Hoeck 1982). Similarly, they would also be vulnerable during the post-release period while finding suitable refuge (Biggins *et al.* 1999; Truett *et al*. 2001).

Failures of some other mammalian re-introductions have been caused by high predation within a few days (e.g. Banks *et al.* 2002; Calvete & Estrada 2004), or months (Ostermann *et al.* 2001; Short *et al.* 1992) after release. This was largely a consequence of high predator density, individuals unfamiliar with the terrain to successfully escape, or they are unfamiliar with the predators in the new area (Ostermann *et al.* 2001). These factors are all likely implicated in the failure of the hyrax reintroduction, while a high predator density is also considered a possible reason for the low hyrax population at the Umgeni Valley Nature Reserve (Fairall & Hanekom 1987). Furthermore, accumulation of waste (as well as increased smell and activity) inside the holding cage, used in the wild rock hyrax release, may have attracted predator/s, as reported elsewhere (Banks *et al.* 2002). Most of those hyrax were found predated in close proximity to the holding cage and release site.

The rock hyrax may have been vulnerable to predation because of small group size or group disintegration upon release, as this has consequences for group vigilance (Hoeck 1975). The group of 17 captive rock hyrax and nine wild rock hyrax were both similar in size to groups of wild rock hyrax, which vary between nine (Fourie & Perrin 1987a), 22 (Druce *et al*. 2006) and 32 (Fourie & Perrin 1987a). Similar group sizes exist on rocky outcrops in Serengeti (nine and 26), but may be as small as two individuals (Hoeck 1982). In addition, rock hyrax have been previously re-introduced successfully onto rocky outcrops in the Serengeti, using only six individuals (Hoeck 1982) and a pair (Hoeck 1989). Therefore, group size (and the resulting composition and cohesion) may be less important than predation in the failure of the releases.

However, the importance of a socially intact group for a successful reintroduction of a social species has been raised in other studies (Kleiman 1989; May 1991; Jordon 2003; Gusset *et al*. 2006). It has not previously been considered important in transporting/reintroducing rock hyrax, as hyrax have been successful reintroduced with individuals from two different colonies (Hoeck 1982). Furthermore, hyrax are generally not thought of as a true social species, because of a lack of social grooming, and high intra-specific aggression (Sale 1970). It is suggested that hyrax are only social as a result of their heat and water physiology (Sale 1970) and vulnerability to predators when feeding alone (Sale 1965a). While feeding, individuals in small groups position themselves so they face outwards in different directions to detect predators, while sentinels, especially the territorial male, warn them of danger (Hoeck 1975). Therefore, in the current hyrax reintroduction, the lack of a socially cohesive group (possibly because of an incorrect group composition and pre-release stress) may have lead to increased vulnerability to predation.

In terms of group composition, a "typical wild group" of rock hyrax, consists of one territorial adult male (older than four years), several adult females and several sub-adults and juveniles of both sexes, but sometimes peripheral males are found loosely associated (Fourie & Perrin 1987a). A female-bonded group is the basic hyrax group structure, and they are usually related to each other (Fourie & Perrin 1987a), but an adult male initiates the colonisation of an area (Gerlach & Hoeck 2001). The "captive" group in the present study was similarly structured, but had four adult males and may have had several unrelated females, as a consequence of capture bias. The time that this group had spent in captivity may have encouraged bonding (Woodford & Rossiter 1994; Hunter *et al*. 2007), as the successful reproduction a year after capture suggests this (Gusset *et al*. 2006). However, time to establish hierarchies and relationships in rock hyrax is unknown, and probably varies between mammal species. In African wild dogs (*Lycaon pictus*) it took 3 months to establish these in a newly formed group, when the bonding process was without human disturbance (Gusset *et al*. 2006). The repeated health checks in this study may have caused additional stress to the hyrax (Dickens *et al*. 2009), and together with pregnancy or lactation as physiological stressors (Fourie *et al*. 1987), bonding may have been affected. The hard release for the one group may have been a contributing factor to group disintegration and dispersal, as found in other studies (Bright & Morris 1994; Gusset *et al*. 2006; Hunter *et al*. 2007). However, the time the "wild" group spent in the holding cage during the soft release may have been too stressful for this group to bond (Dickens *et al*. 2009), as indicated by cannibalism and mis-mothering of pups (Calvete *et al*. 2005). Disintegration of both rock hyrax groups in both releases may have increased their vulnerability to predation.

Although it is considered better to capture family groups (Shier 2006), the method of capturing all individuals in a colony, marking them for individual identification, then releasing them back to the colony so that family groups can be determined and then capturing these groups (Shier 2006), is impractical for use in rock hyrax. Furthermore, since rock hyrax show no sexual dimorphism (Hoeck 1982) and family groups are indistinguishable in a colony (pers. obs), the capture of family groups without individual marking is unlikely. Groups could thus be artificially constructed to resemble the wild group composition and should be allowed to bond for several months before release (Kleiman 1989; Jordon 2003), preferably long enough to breed and for the young to be several months old (Gusset *et al*. 2006). However, this could result in other problems such as disease and stress during captivity. This was observed in our study, and been shown in other captive situations. Rock hyrax, mostly the males, are often aggressive to each other when kept together in zoological garden exhibits, and so are generally kept in small groups (about 4) and males separated (Anon 2006). Wild pregnant females taken into captivity have shown considerable stress, particular a few days before and during parturition (Sale 1965b).

To improve the success of future hyrax introductions, we have the following suggestions. We suggest that a thorough search and estimation of predators in the release area should be conducted. If high, then one should consider actively deterring predators for a period after release (Calvete & Estrada 2004; Shier 2006), or consider another release site. Capture of hyrax in KZN should be restricted to April to June, for ease of capture (low food availability in dry winter makes them easier to bait in traps), avoidance of heavily pregnant females, and pups should be weaned (1 to 5 months after birth (Miller 1971)). However, it is difficult to avoid capture of pregnant females, as they have an eight month gestation (Miller 1971). Future studies should investigate the benefits of hard versus soft release. A suggestion for use in a soft release is to have a larger holding cage at the release site (at least three times bigger than that used in this study), which includes a rocky habitat, with crevices, that could be explored by the hyrax before release. They would then have the opportunity to establish areas and paths needed to escape from predators (Jordon 2003). Post-release monitoring, especially with radio-telemetry, is essential to determine the fate of rock hyrax after release.

In conclusion, the reintroduction of captive and wild rock hyrax appeared to have failed because of predation. This may have been a consequence of group disintegration, resulting from incorrect group composition, captive stress, and type of release. Only with post-release monitoring using radio-collars, was the fate of rock hyrax released into a reserve in South Africa known. Therefore, based on the findings of this study, high mortality of rock hyrax bought from wildlife auctions or removed in pest-control and released into areas in South Africa is likely, unless methods are improved. Further research is needed.

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Table 1. Locations of sites used by captive rock hyrax after release and the number of days they occupied the site.

Site occupied	No. of days at site (since release)	Distance and direction from release site
Site 1 (release site)	0 – 45	0
Site 2	4 – 6	173.6 m, west
Site 3	13 – 61	74.3 m, east
Site 4	18 – 87	164.4 m, east
Site 5	28 – 51	212.4 m, east

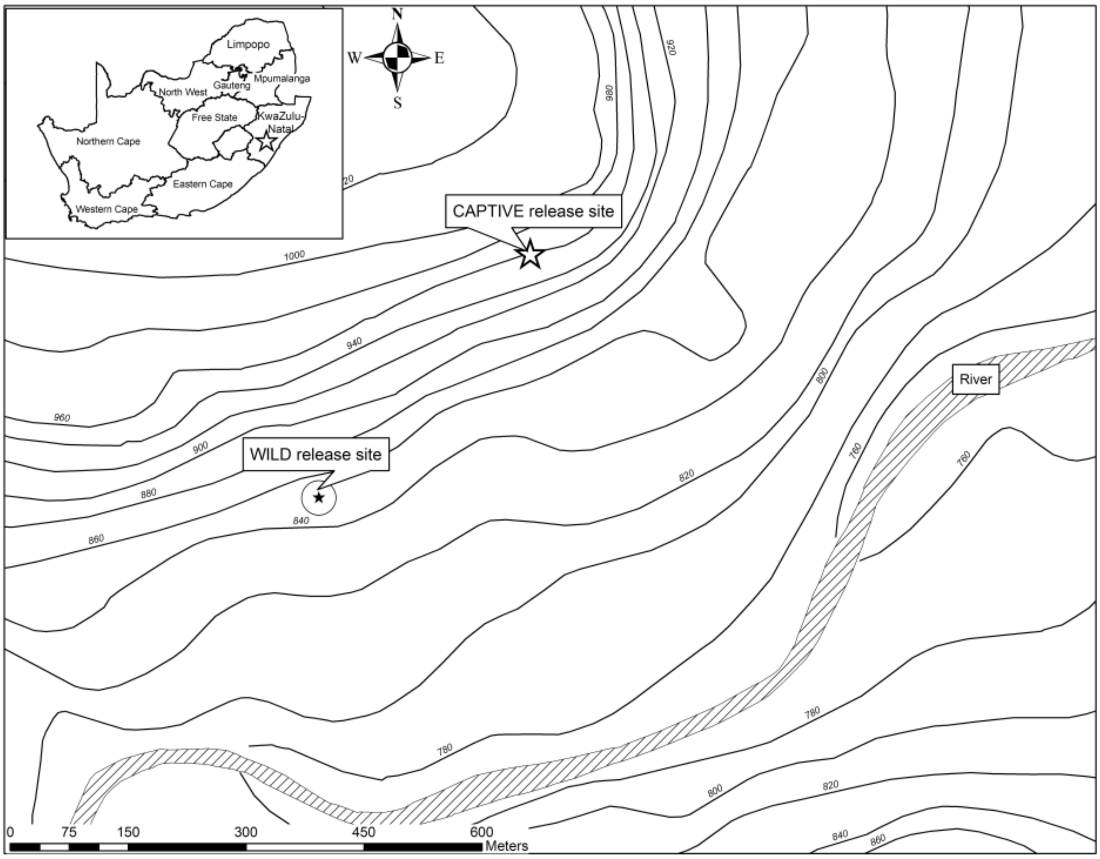
Table 2. Fate of all wild rock hyrax released, in the order of when their radio-collars were found, and how far this location is relative to the release site. Due to finding an unidentified rock hyrax spine together with H4, it is presumed that either H1 or H8 was killed.

Hyrax	Days after release	Distance from holding cage (m)	Fate and cause	Details of remains found
H1	N/a	N/a	Unknown	Did not have collar attached
H5	2	41	Dead (predation)	Intact stomach and intestine removed from body, the skin left intact (refer to text for more detail).
H9	4	18	Dead (predation)	Similar to H5
H8	5	109	Unknown	Collar was self-removed
H4	7	10	Dead (predation)	Similar to H5
H6	8	624	Dead (predation)	One bone
H7	8	74	Dead (predation)	Similar to H5
H3	11	1400	Dead (accident)	No injuries, on vegetation in river
H2	18	221	Dead (predation)	Similar to H5

Figure Legends

Fig. 1. Locations of release sites for captive and wild rock hyrax within Umgeni Valley Nature Reserve, KwaZulu-Natal, South Africa.

Fig. 2. Minimum number of captive rock hyrax seen over 120 days since they were released



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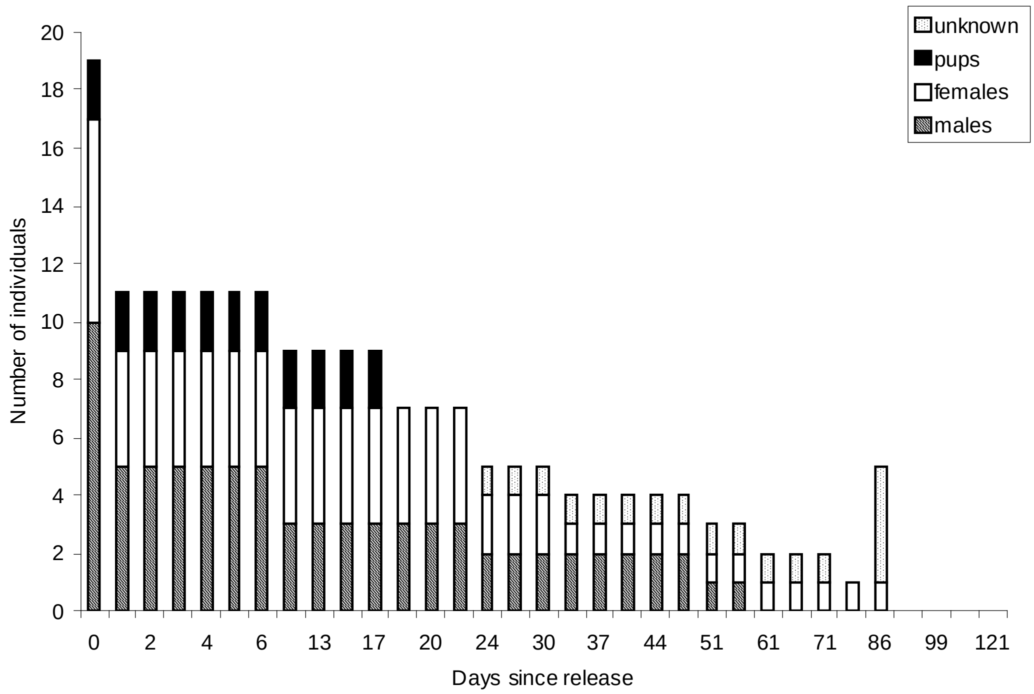

Fig. 2. Minimum number of captive rock hyrax seen over 120 days since they were released

CHAPTER 7

Conclusion: Wildlife rehabilitation in South Africa

Format followed as for Animal Welfare

"If I can stop one heart from breaking,
I shall not live in vain;
If I can ease one life the aching,
Or cool one pain,
Or help one fainting robin
Unto his nest again,
I shall not live in vain."
Emily Dickinson (1830-1886)

As this poem suggests, wildlife rehabilitation is often driven by emotions. As humans, we understand the urge to help an animal in distress and to take it to someone who will take care of it: either hand-raise it, fix its injury and release it, or put it humanely out of its misery. This is what wildlife rehabilitation is fundamentally about, but it was not the focus of my thesis. I wanted to determine objectively whether human emotion may result in more rather than less animal suffering and possible detriment to the existing wild populations. In other words, I set out to determine the efficacy of wildlife rehabilitation, particularly in South Africa.

I started by estimating the degree of dichotomy between wildlife rehabilitation and conservation efforts, and necessity of adoption and enforcement of wildlife rehbailitation norms and standards, by providing the first ever assessment of rehabilitation centres in South Africa, in terms of numbers of centres and animals, the species rehabilitated, pre- and post-release protocols, and economics (Chapter 2). Out of 63 known rehabilitation centres throughout nine provinces in the country, 65% returned questionnaires. They dealt with a variety of taxa, and ranged from specialist centres dealing with a few animals a year, to large generalist centres receiving up to 3600 animals annually. As there are many animals in need of care, and as the public is willing to take animals to the centres, there is clearly a need for wildlife rehabilitation. Rehabilitators want their field to be more professional (through minimum standards and enforcement), but lack of communication between the rehabilitators, lack of experience and empathy by government wildlife officials (who issue them permits), and lack of money, are the main obstacles to achieving this. This situation is not unique to South Africa (e.g. Canada: Dubois & Fraser 2003a, b). The problems with wildlife officials resulted in rehabilitators regarding them with antagonism and therefore, rehabilitators are cautious in them being involved in the development and enforcement of minimum standards.

However, due to insufficient research on rehabilitation methods, and minimal post-release monitoring, I found that work experience and subjective intuition drove most rehabilitation practices. Additionally, because personnel from most centres cited a lack of finance as a main impediment to the goal of rehabilitation, the result of rehabilitation may include negative impacts on individual animal welfare and survival, as well as on conservation. I therefore suggested that wildlife rehabilitation be centralised to the national or provincial government, and that minimum standards should be developed in consultation with experienced rehabilitators, veterinarians and conservation scientists, and be enforced by trained wildlife conservation officials.

To gain further insight into the need for wildlife rehabilitation in a community in South Africa, I decided to focus on the intake records of a large rehabilitation centre based in the suburbs near to one of the largest cities in KwaZulu-Natal, and to analyse these (Chapter 3). This generalist centre admits a wide variety of animal taxa; over four years there was an intake of 12948 individuals from 208 species, with 2701 being admitted annually. Most of the intake (90%) was birds, with few mammals (8%) and reptiles (2%), and most were of locally common species (eg doves, pigeons). This reflects the findings of previous studies, namely that species living in close association with humans are the most frequently admitted to rehabilitation centres (Deem et al. 1998). Most of the animals admitted (43%) were juveniles, which were assumed to be abandoned or orphaned. The implications of rehabilitating the largely uninjured juveniles, is whether humans should interfere with nature if the cause was not human-related (see Kirkwood 1992). Furthermore, can each juvenile (especially in these large numbers) be adequately prepared to survive and thrive when released into the wild; and is there space in the environment for them, without causing harm to others already present? I suggested that the large numbers of animals currently being admitted to the centre may be reduced through increased public education, particularly to leave non-orphaned and uninjured juveniles in the wild (see Jacobs 1998). Furthermore, I suggested that improvements to the centre's recording system be made to may allow for use in funding requests and for various research opportunities, such as identifying the threats to wildlife (e.g. Harden et al. 2006).

Given the general lack of post-release monitoring in wildlife rehabilitation, particularly in South Africa (e.g. Chapter 2), and because the IUCN advises that confiscated (IUCN 2000) and orphaned (Soorae 2005) animals rather be euthanased or placed in life-time captivity, I documented the post-release fate of rehabilitated vervet monkeys (Chapters 4) and Babcock's leopard tortoises (Chapter 5), two species commonly admitted to a rehabilitation centre (Chapter 3). I presented the post-release monitoring of a third species, rock hyrax (*Procavia capensis*), as a further case study, even though individuals were not from a rehabilitation centre (Chapter 6). In these case studies, the issue of defining success was raised. I believe that success of releasing rehabilitated animals cannot be judged on whether it results in a self-sustaining population, as in reintroductions (Dodd & Siegel 1991; IUCN 1998). In that scenario, even if all reintroduced individuals died soon after release, but the release resulted in the species' habitat being protected, the reintroduction would still be a success (Kleiman 1989). I see the goal of releasing a rehabilitated animal to be different, as it is to improve the welfare of that particular animal, independent of its species' status. Survival is thus the most basic indicator of a successful rehabilitation release because an ill-prepared animal would likely die soon after release (Waples & Stagoll 1997; Beringer et al. 2004). Furthermore, because rehabilitated animals have to go through the stress and fear of captivity and possible pain of healing (BWRC 1989 in Kirkwood 1992), I concur with other authors (e.g. IAAWS 1992) that rehabilitated animals should be at no greater disadvantage to living in the wild than their wild conspecifics of similar age, gender and status. This means that rehabilitated animals should survive for a similar length of time to wild conspecifics (IUCN 2000; Goldsworthy et al. 2000; Molony et al. 2006) and the cause of any deaths should be natural and not as a result of other factors (e.g. not adjusting to release site). Other aspects, such as behaving similarly to a wild animal (Box 1991), establishing in an area (Ostro et al. 1999), and having no dependency on humans for food and/or companionship (outside the time needed for a soft release) (Cheyne & Brulé 2004; Grundmann 2005); are all additional success factors as they likely influence survival.

Although after one year post-release, the two troops of vervet monkeys (including an infant) survived, were independent of human food provision and companionship, had established in an area, and had births in the breeding season following release, the large numbers of missing individuals as well as known mortalities make it difficult for me to say with conviction that the releases were successful (Chapter 4). However, it was clear that the two groups of rock hyrax released were not successful (Chapter 6). Even though there were no known deaths in the first group released, I assumed a high mortality, because the group disintegrated after release, and all (except one) of the second group were found dead within 18 days. For both vervet monkeys and rock hyrax, I suggest a lack of social cohesion as causing the group to dissolve or split upon release, which in turn would likely increase their vulnerability to predation (Chapters 4 and 6). This result is particularly interesting for future translocations of rock hyrax, as they have never been considered trule social species, because of a lack of social grooming, and high intra-specific aggression (Sale 1970). Thus my main suggestion to improve success of future rock hyrax and vervet monkey releases includes ways of improving social cohesion of groups before release (see Chapters 4 and 6 for further suggestions). However, I suggest that other factors may have influenced success, such as a high predator density in the release habitat, and the released animals being vulnerable to predation by being unfamiliar with the terrain to successfully escape and being unfamiliar with predators in the new area (Ostermann et al. 2001). For vervet monkeys, I believe it is essential that all individuals admitted to the centre are individually identified and their history documented, so that future research could test whether this may influence group cohesion and/or success of a release. The benefits of individual identification are likley applicable to other species admitted to wildlife rehabilitation centres.

Kleiman (1989) suggests that species need different amounts of of pre-release training in behaviours most likely to affect survival. For instance, in the context of non-domesticated species, herbivores (e.g. ungulates) bred or raised in captivity may not need to be taught how and what to forage (as the behaviour is hardwired, Kleiman 1996), compared with omnivores (e.g. primates) and carnivores (Kleiman 1989). Similarly, as a result of infant reptiles functioning (e.g. foraging) as adults, with no parental care to guide them (Allman 2000), it has often been assumed that behaviour of reptiles is mainly "instinct driven". This has given the impression that rehabilitated tortoises could be successfully released back into the wild. However, high post-release mortality in the one group of Babcock's leopard tortoises showed otherwise, especially as many died because of starvation or dehydration and/or disease (Chapter 5). Thus to improve success of future releases of leopard tortoises I suggest that they are kept in holding cages at the release site to allow them to become accustomed to food and diseases present at the release site, or for diseases to reveal themselves (Dodd & Siegel 1991). However, the costs in relation to this species' conservation status make this intervention unlikely to be practical. I have, therefore, also suggested other changes to the release protocol, such as releasing them in a less undulating terrain (Chapter 5). The occurrence of disease in the tortoise release was a worrying result, and must be addressed before any further releases are allowed (Chapter 5).

Consequently, I suggest that health and disease checks must be conducted on every rehabilitated animal before it is released. However, does that mean that every single dove (e.g. 700 individuals each year: Chapter 3) or hadeda ibis (*Bostrychia hagedas)* must be screened for diseases before release? Or perhaps only large animals, only mammals, or those admitted in fewer numbers? The problem is the lack of knowledge of diseases affecting each of the 208 species (Chapter 3), the practicality of checking 2701 individuals annually (Chapter 3) and of course, lack of money, time and resources available to do this (Chapter 2). This dilemma is also relevant to preparing an animal for release, because it is not known which behaviours are learnt (Kleiman 1996); and whether losing fitness while in captivity is as important to survival for all animal species as it is in rehabilitated raptors (Curtis & Jenkins 2002). I recommend that priorities be defined, perhaps based on species rarity, as generally only half the number of individuals admitted is actually released (Dubois 2003; Molony et al. 2007). Furthermore, in this study it was evident that a lack of funding and resources were available to monitor the post-release success of common species'. There were also limited resources available for extensive surveys to determine the suitability of the release habitat, such as the presence of wild conspecifics, and also for lengthy soft-release protocols, such as having tortoises penned for 12-months at the release site. I am not saying that the rehabilitation and release of common species should be halted, but that one must be careful in assuming that it is easy to successfully release rehabilitated animals into the wild if they are a common species. I have demonstrated that this was not the case in two case studies where I monitored the post-release success of common animals that were rehabilitated and released according to established rehabilitation techniques.

I believe that I have presented enough evidence in the thesis to suggest that wildlife rehabilitation may result in negative consequences to the welfare of the individual being rehabilitated and to the wild species in the release site, which is likley to affect conservation. I feel it is thus important for adjustments in wildlife rehabilitation to be made, such as an increased involvement of qualified governmental wildlife conservation officials who would develop and enforce practical minimum standards. I also encourage that more research is conducted on all aspects of wildlife rehabilitation, as there is scant data available, and this should include comparative studies documenting the success of releasing rehabilitated animals after different rehabilitation techniques (e.g. Kelly et al. 2008).

To summarise, there is a dichotomy between wildlife rehabilitation and conservation throughout the world, but this study highlighted the situation in South Africa. Mostly common species are being admitted to rehabilitation centres, to be hand-raised and healed, and then released, which makes it difficult to follow the IUCN guidelines. However, the IUCN (IUCN 1998, 2000) makes it clear that there are many threats to the individual animal, to the release environment and to the conservation of species when transporting and releasing animals, especially if they had been in captivity. I believe that the same threats apply to transporting and releasing rehabilitated animals, but because there are so many wildlife rehabilitation centres throughout the world, the threats to the environment could be even greater than that suggested (IUCN 2000). However, the applicability of the IUCN guidelines will vary slightly according to the species and situation, and they require input from the local conservation authorities (as was the case in the studies documented in this thesis). As a result of increasing urbanisation and increased human-wildlife conflict (Kretser et al. 2008; Hubbard & Nielsen 2009), there will be continued and increasing need for rehabilitation, in order to offset man's impact on wildlife (Holcomb 1995), and thus it is urgent that adjustments are made to the management of wildlife rehabilitation.

Wildlife rehabilitation needs to move away from an emotional-based "animal-rights" organisation, such as treating and releasing exotic animals, to being objectively managed, such that no harm is caused to conservation by these efforts or animal welfare. This may require them to change their constitution so they are aligned with the IUCN guidelines, where more consideration is given to the possible risks involved in releasing animals. Furthermore, development and enforcement of practical minimum standards, and compulsory certification programmes, will hopefully exclude those rehabilitators who feel they have earned their right to take care of wildlife, only as a result of their dedication (taking care of wildlife "24/7/ 365 days a year": Kosch-Davidson et al. 2006, p4). The incorporation of "science, ethics and legal regulation" has been mentioned in the context of improving marine mammal rehabilitation (Moore et al. 2007, p745), and the same is suggested here. Furthermore, I suggest that the public be educated as to the risks that wildlife rehabilitated animals can pose to the safety of the environment as a whole, and that rehabilitated animals do not necessarily survive or thrive in the wild when released (Chapter 4 and 5), and thus they have to understand that rehabilitation centres will sometimes have to prioritise casualties for treatment (i.e. "triage", Molony et al. 2007), and euthanase exotic species. In conclusion, implementing further research in ensuring long-term post-release survival of rehabilitated animals; developing and enforcing practical guidelines/minimum standards by dedicated and qualified governmental wildlife conservation officials; and having examinations in order to qualify as a wildlife rehabilitator, will ensure humans are "making amends" (Aitken 2004) instead of having an additional negative impact on conservation and animal welfare.

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