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REVIEW ARTICLE

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Giraffe translocations: A review and discussion of considerations

Zoe Muller[1,2] | Derek E. Lee[3,4] | Ciska P. J. Scheijen[5,6] | Megan K. L. Strauss[7] | Kerryn D. Carter[8] | Francois Deacon[5]

[1]School of Biological Sciences, Life Sciences Building, University of Bristol, Bristol, UK

[2]Giraffe Research & Conservation Trust, Nairobi, Kenya

[3]Wild Nature Institute, Concord, NH, USA

[4]Mueller Laboratory, Department of Biology, Pennsylvania State University, State College, PA, USA

[5]Wildlife and Grassland Sciences, University of the Free State, Bloemfontein, South Africa

[6]Rockwood Conservation, Griekwastad, South Africa

[7]Independent researcher, Upwey, Vic., Australia

[8]Elephant Connection, Kavango Zambezi Transfrontier Conservation Area, Mwandi, Zambia

Correspondence
Zoe Muller, School of Biological Sciences, Life Sciences Building, University of Bristol, 24 Tyndall Avenue, Bristol BS8 1TH, UK.
Email: muller.zoe@gmail.com

Abstract

Giraffe populations have declined dramatically in the last three decades. Giraffe translocations are likely to increase as wildlife managers seek to augment or re-establish populations. Currently, formal practical guidance for giraffe translocations is limited. Here, we present a review of translocation guidelines emphasising planning, implementation, monitoring and evaluation, and we review giraffe behaviour and ecology to provide recommendations specific to the translocation of giraffes. We also aim to stimulate discussion about best practices for giraffe translocations and further research into the ethical and practical considerations of moving giraffes.

KEYWORDS

conservation, giraffe, population management, reintroduction, translocation

Résumé

Les populations de girafes ont considérablement diminué au cours des trois dernières décennies. Les transferts de girafes sont susceptibles d'augmenter à mesure que les gestionnaires de la faune cherchent à augmenter ou à rétablir les populations. Actuellement, les conseils pratiques formels pour les transferts de girafes sont limités. Ici, nous présentons un examen des directives de transfert mettant l'accent sur la planification, la mise en œuvre, le suivi et l'évaluation, et nous examinons le comportement et l'écologie des girafes pour fournir des recommandations spécifiques au transfert des girafes. Notre objectif est également de stimuler la discussion sur les meilleures pratiques pour les translocations de girafes et de poursuivre les recherches sur les considérations éthiques et pratiques du déplacement des girafes.

1 | INTRODUCTION

Translocations are human-mediated movements of species from one area to another, within or outside a species' historical native range (Armstrong & Seddon, 2008; IUCN, 2013). Translocations are generally undertaken for commercial gain (purposes of breeding, hunting or ecotourism), or conservation purposes (IUCN, 2013; Seddon, Armstrong, & Maloney, 2007). Conservation translocations are typically used to reintroduce species into areas where they have become extirpated, to augment locations with small or declining populations (Armstrong & Seddon, 2008), or to protect genetic diversity (Deacon & Tutchings, 2019; Muller, 2019). Removal of the original threatening factor (e.g. illegal hunting, disease, introduced predators) prior to reintroducing animals is pivotal to success of the programme (IUCN, 2013). The prime objective of any translocation should be the long-term, self-sustaining viability of both the donor and translocated populations, achieved without harming other wildlife species, plant communities, or people.

Giraffes (*Giraffa camelopardalis*) are classified as Vulnerable on the IUCN Red List due to a 40% decline in numbers between 1985 and 2015 (Muller et al., 2016). Giraffe translocations have occurred within, and between, multiple African countries, for example South Africa (Deacon & Tutchings, 2019), Namibia (Flanagan, Brown, Fennessy, & Bolger, 2016), Kenya (Dagg, 2014; Muller, 2019; Nesbit Evans, 1970), Uganda (Muller, 2019), Senegal (Malyjurkova, Hejzlarova, Vymyslicka, & Brandlova, 2014), Niger (Le Pendu, Ciofolo, & Gosser, 2000) and Malawi. Even though numerous giraffe translocations have been conducted, very few published accounts describe them, and there is little formal guidance how best to plan, implement, or report them. Giraffes have unique biology and physiology presenting unique challenges during their capture and transport (Brøndum et al., 2009; Damkjær et al., 2011; Mitchell & Skinner, 2009; Mitchell, van Sittert, & Skinner, 2009; van Sittert, Skinner, & Mitchell, 2010). A manual published by the Giraffe Conservation Foundation (Fennessy et al., 2019) provides a summary of practical specifics of capture and handling giraffes during translocations, but little consideration to planning, justification criteria, population viability analysis, habitat assessments, population and ecological monitoring, or reporting of outcomes. This paper extends the discussion around giraffe translocations by offering decision-making, planning, monitoring and evaluation guidance. We provide a literature review of available translocation guidelines, and information about adapting these to the translocation of giraffes.

2 | METHODS

2.1 | Literature review

We examined peer-reviewed journal articles, online reports, books, conference abstracts and technical reports. We focused on accounts of giraffe translocations, of which there are few. We also reviewed the body of literature on giraffe behaviour, ecology, distribution and management, resources that were focused on translocation events themselves, and translocation lessons learned from other species. In some instances, we included our personal experiences, based on observations and knowledge of working with giraffes in the field.

3 | INITIAL PLANNING AND JUSTIFICATION

Initial planning should follow a logical decision-making process that involves all relevant stakeholders. Steps should be taken to discuss and document: (a) the necessity of the proposed translocation; (b) the risks to giraffes and other species, including people at the source and translocation sites; and (s) technical and logistical suitability (IUCN, 2013; Pérez et al., 2012; section 3). The definition of the programme's success (e.g. population size, growth rate, distribution and long-term persistence) should be decided at the outset so that it is clear to participants whether the programme was successful or not in terms of the original goals (Converse, Moore, & Armstrong, 2013). The planning process should define clear, specific, measurable goals and develop a robust monitoring and evaluation process and schedule (Converse et al., 2013; IUCN, 2013; Salafsky & Margoluis, 2003; Salafsky, Margoluis, Redford, & Robinson, 2002; Stem, Margoluis, Salafsky, & Brown, 2005). Within these three critical areas, Pérez et al. (2012) suggest ten criteria for evaluating translocation projects, including a hierarchical decision-making system for translocations. Full compliance with the ten criteria implies that a translocation project is justifiable and ensures any issues that could compromise project success have been assessed and the outcomes fully considered (Pérez et al., 2012). Justifying the necessity of a translocation requires a high level of confidence regarding long-term population viability in both the donor population and at the release site (IUCN, 2013). During the planning of any translocation event, expected benefits must be weighed against potential risks. Decision-making processes should be formal and transparent, based on evidence and facts, not assumptions.

We suggest that the process of adaptive management (Williams, 2011; Williams & Brown, 2014) provides another useful framework for translocation planning, by utilising learning-oriented decision-making in the context of natural resource management. Adaptive decision-making is based on the recognition that resource systems are only partially understood, and there is value in continually monitoring resource conditions and applying what is learned as the resources are being managed (Williams, 2011; Williams & Brown, 2014). In the ongoing process of learning and adaptation, adjustments to decision-making occur as understanding improves, with the ultimate goal of improved management (Stankey, Clark, & Bormann, 2017). Given that giraffe translocations have only been recorded since the 1970s (Dagg, 2014; Muller, 2019), and there are no data to support their long-term success, they must still be considered an experimental approach to conservation, suitable to the adaptive management approach.

Population viability analysis (PVA) is a useful tool for modelling the potential trajectory of populations, given various sets of starting conditions, and can be used to estimate the probability of population extirpation within a given number of years (Boyce, 1992; Morris & Doak, 2002). PVA can predict translocation outcomes and should be central to any translocation planning and decision-making process (Dimond & Armstrong, 2007; IUCN, 2013). PVA simulations have shown that in order to establish a long-term (100 years), genetically viable population of giraffes, a minimum of 30 females is required for the founding population (Lee et al., 2019). This is a substantially higher figure than is usually moved in practice (Chege, 2008; Muller, 2019).

Translocation planning should also include a formal and transparent risk assessment, to mitigate risks for both people and animals. Potential risks in the translocation of giraffes include death or injury to the giraffes being translocated, or to the people involved, damage to equipment and the environment, or selection of unsuitable individuals or sites which may cause the translocation to fail. We recommend the Translocation Tactics Classification System, which includes both animal- and environment-focused tactics, and an holistic approach to developing translocation plans and assessing risks (Batson, Gordon, Fletcher, & Manning, 2015).

4 | SELECTING INDIVIDUALS FOR TRANSLOCATION

4.1 | Giraffe social structure and behaviour

Giraffes are a social species, with long-term female bonds driven by kinship (Bercovitch & Berry, 2013b), home range overlap (VanderWaal, Wang, McCowan, Fushing, & Isbell, 2014), social preferences (Carter, Seddon, Frère, Carter, & Goldizen, 2013), behavioural state (Muller, Cantor, Cuthill, & Harris, 2018), environmental disturbance (Muller, Cantor, et al., 2018; Muller Cuthill, & Harris, 2018a) and age (Bercovitch & Berry, 2013a; Carter, Brand, Carter, Shorrocks, & Goldizen, 2013). There is limited evidence for long-term bonds in males (Bercovitch & Berry, 2014). In social species, the fitness consequences of maintaining social bonds and family groups are well documented (Silk, Alberts, & Altmann, 2003; Silk et al., 2009, 2010). Associating with older kin also has important survival consequences (Brent et al., 2015; Lahdenperä, Mar, & Lummaa, 2016). If animals are captured and released in family or social groups then stress is reduced and translocation success increased (Gusset, Slotow, & Somers, 2006; Litoroh, Omondi, Bitok, & Wambwa, 2001; Omondi, 2002; Omondi, Bitok, & Kagiri, 2004; Pérez et al., 2012; Pinter-Wollman, 2008; Slotow, Garai, Reilly, Page, & Carr, 2005), and release-site fidelity is more likely (Bradley et al., 2005). Giraffes, like many other highly social species, are likely to receive fitness and survival benefits from close associations (Silk et al., 2003, 2009,). We advocate keeping groups of closely bonded giraffes together during translocations, particularly groups of bonded females and calves born within the same cohort (Bercovitch & Berry, 2013a; Carter, Brand, et al., 2013). Typical group size in giraffes ranges from 1 to 46 (Muller, Cantor, et al., 2018; Muller Cuthill, & Harris, 2018b) but is highly influenced by environmental and social variables. Therefore, precapture monitoring of social associations should be used to identify long-term bonds within the source population, so that stable social groups can be moved together, to provide the best chances of survival.

4.2 | Source population

Planners should use PVA to quantify the viability of the remaining source population (Armstrong & Seddon, 2008; Dimond & Armstrong, 2007). Selective removal of animals has been shown to change behavioural and biological processes (Carne, Semple, Morrogh-Bernard, Zuberbuhler, & Lehmann, 2014; Williams & Lusseau, 2006). A full assessment of the impact of the removal of individuals is necessary and has the potential to reduce negative impacts and increase translocation success (Bustamante, 1996; Dimond & Armstrong, 2007; Kafley et al., 2015; Lacy, 1987).

4.3 | Genetics

Given the current uncertainty over giraffe taxonomy (Bercovitch et al., 2017; Fennessy et al., 2016), long-term isolation of some populations (e.g. *G. c. thornicrofti*), and deleterious effects of inbreeding depression (Lackey, 2009; Lee et al., 2019), genetic factors should be considered in giraffe translocation events. Guidance regarding taxonomic classification and distribution of giraffes is available from the IUCN SSC Giraffe and Okapi Specialist Group (www.giraffidsg.org), and general genetic diversity advice is available from population biologists experienced with small-population genetics. The taxonomic position of any population affected by translocation should be investigated (van Niekerk, Deacon, & Grobler, 2019). Creating hybrid populations, which will have reduced reproductive fitness, should be avoided at all costs (Frankham et al., 2011; IUCN, 2013). Translocations will be most effective if high levels of genetic diversity are maintained within subpopulations (van Niekerk et al., 2019), and mimic patterns of natural gene flow (Goossens et al., 2005). Inbreeding depression is reduced when larger numbers constitute the founding population (Lee et al., 2019).

5 | RELEASE-SITE CONSIDERATIONS

5.1 | Spatial requirements

Home range sizes of wild giraffes range from 5 to 1950 km^2 (Knüsel, Lee, König, & Bond, 2019). Space use is typically related to rainfall, habitat quality and forage availability (Deacon & Smit, 2017; Knüsel et al., 2019; Pellew, 1983a), highlighting the importance of these factors when selecting release sites. Giraffe ranging and movement patterns are understudied (Lee & Bolger, 2017), but there is evidence that females show site fidelity (Bercovitch & Berry, 2015; Brand, 2007; Carter, 2013; Dagg & Foster, 1976; Langman, 1973b). Males roam between female herds to assess their reproductive status (Bercovitch, Bashaw, & del Castillo, 2006). In Kenya, 11 Rothschild's giraffes were translocated and initially established themselves at the release habitat, but after 14 weeks they moved out of the area and were never relocated (Nesbit Evans, 1970). Fencing used to restrict dispersal and deter predators, and/or poachers should be 2.4 m high (Brown, Gildenhuys, Hignett, & Deventer, 2014), and sturdy, as giraffe may lean against the fence (Jolly, 2003). Regular patrolling and monitoring of fences is essential to detect whether any damage, poaching, escapes, or intrusion by predators has occurred. Electrified fences can be used; however, giraffes have been known to break electric fences if they are spatially restricted (McKillop & Sibly, 1988).

5.2 | Habitat suitability and nutritional requirements

Habitat assessments of potential release sites are essential to quantify resource availability and to understand potential ecological impacts on the release habitat from the translocated population (Bond & Loffell, 2001; Deacon, 2015). The size of the release site and habitat quality must be sufficient to meet the needs of translocated animals (nutrition, water and vegetation cover) during all life stages and across all seasons, taking into account resident predators, competitors and current/future land uses (IUCN, 2013). Animals are more likely to successfully establish at a release site if it has habitat similar to the source site (Osborne & Seddon, 2012; Parlato & Armstrong, 2013). Novel forage species and new environments contribute to elevated stress levels and slow rates of acclimatisation, which influence survival and reproduction rates (Clayton, Pavey, Vernes, & Tighe, 2014; Letty, Marchandeau, & Aubineau, 2007; Parker, Dickens, Clarke, & Lovegrove, 2012; Teixeira, Azevedo, Mendl, Cipreste, & Young, 2007) and increase postrelease dispersal (Berger-Tal & Saltz, 2014; Richardson, Doerr, Ebrahimi, Lovegrove, & Parker, 2015; Stamps & Swaisgood, 2007). Surveys are necessary to document differences and similarities between source and release sites, especially concerning vegetation, predators and competitors (Clayton et al., 2014; Hayward et al., 2010; Letty et al., 2007; Parlato & Armstrong, 2013), reserve size, fencing (Bariyanga, Wronski, Plath, & Apio, 2016; Gusset, 2010), and parasites and diseases (Armstrong & Seddon, 2008; Ewen et al., 2012).

The relationship between habitat quality, stocking rate (the number of animals inhabiting a piece of land, i.e. giraffes/ha) and animal production is well-established (Gandiwa, 2014; Mentis & Collinson, 1979; Ogutu et al., 2016). Stocking rate impacts animal performance and forage resources because it directly influences animal productivity, forage production, forage quality, long-term plant species composition and plant physiology (Janecke & Smit, 2011). Optimal stocking densities for giraffes have not been studied. However, there is evidence that if giraffes are restricted to enclosed areas of habitat, vegetation can be damaged, and permanent changes can occur to species composition and diversity (Birkett, 2002; Bond & Loffell, 2001; Fleming, Hofmeyr, Nicolson, & Toit, 2006; Furstenburg & Van Hoven, 1994; Zinn, Ward, & Kirkman, 2007).

When selecting potential release sites for giraffe translocations, the availability and abundance of forage species preferred by giraffes should be documented. Giraffes forage on over 100 species of vegetation, and diet varies regionally and seasonally. There is a consistent preference for *Acacia* species (Berry & Bercovitch, 2016; Deacon & Smit, 2017; Pellew, 1984). Giraffes do not consume food in proportion to its availability (Dagg, 2014), rather plant species that giraffes preferred may comprise <5% of the total available biomass (Pellew, 1983a). Adult giraffes consume 16.6–19 kg of dry matter per day (Pellew, 1984), and their diet is composed of leaves and shoots, seed pods, flowers and herbs (Fleming et al., 2006; Pellew, 1983a). Giraffes select food with higher protein content (Pellew, 1983a), 14%–16% of diet for maintenance and up to 18%–20% of diet during growing phases and lactation (Fowler, 1978; Meissner, 1982). Giraffes avoid plant species with chemical defenses such as phenols and condensed tannins (Furstenburg & Van Hoven, 1994; Pellew, 1984; Strauss, Kilewo, Rentsch, & Packer, 2015). Abnormal feeding behaviours observed in giraffes (e.g. pica, osteophagia, bark-stripping) may indicate nutritional stress (Bothma, 2002; Langman, 1978) which can be alleviated through the provision of supplementary mineral licks (Deacon, 2015).

Large herbivores can affect the structure and woody plant species diversity of woodlands and savannahs (Asner et al., 2009; Bakker, 2003; Bond & Loffell, 2001; Strauss et al., 2015), especially in enclosed areas (Brenneman, Bagine, Brown, Ndetei, & Louis, 2009). Giraffe browsing significantly reduces the height of *Acacia drepanolobium* (Birkett, 2002; Birkett & Stevens-Wood, 2005), *Acacia tortilis* and *Acacia hockii* trees (Pellew, 1983b). Giraffes also impact *Acacia nigrescens* trees through heavy browsing and removal of flowers which affected pollination (Fleming et al., 2006). Giraffes can cause high levels of mortality in *Acacia* species and have extirpated *Acacia davyi* in some regions (Bond & Loffell, 2001). Giraffe browsing also increases plant susceptibility to fire, drought and other causes of mortality (Birkett & Stevens-Wood, 2005; Bond & Loffell, 2001),and can significantly reduce woody cover (Norton-Griffiths, 1979; Pellew, 1983a, 1983b), which may induce trophic cascades (Sinclair et al., 2010; Terborgh & Estes, 2013).

The ingestion of high levels of tannin has a detrimental effect on a wide range of browsers, including reduced growth, digestion, protein availability, impaired nutritional uptake during digestion and high levels of toxicity (Barry & McNabb, 2007; Kibon & Maina, 1993; Lowry, McSweeney, & Palmer, 1996; Paolini et al., 2003). *Acacia* species increase tannin levels rapidly in response to browsing (Furstenburg & Van Hoven, 1994; Zinn et al., 2007), with higher concentrations appearing in leaves located in the typical browsing zones favoured by giraffes (Woolnough & du Toit, 2001). Pregnant giraffes actively avoid foods with a high tannin content, suggesting that it may be detrimental to the foetus (Caister, Shields, & Gosser, 2003). The over-browsing of *Acacia* species by giraffes in Lake Nakuru National Park in Kenya may have created dietary complications, leading to low recruitment in that population (Brenneman et al., 2009; Muller, 2018). Given that declines of translocated giraffe populations have been observed, likely as a consequence of overstocking and insufficient availability of suitable vegetation (Brenneman et al., 2009; Kenya Wildlife Service, 2002; Muller, 2018, 2019), the impacts a group of translocated giraffes may exert upon a release site must be accounted for, particularly if it is enclosed.

5.3 | Competition with other herbivores

Giraffe food quantity depends on the available biomass in an area and the abundances of all browsers (De Knegt, Groen, Vijver, Prins, & Langevelde, 2008). Low plant species diversity may cause competition between herbivores, particularly during dry periods when food is limited (Parker, 2008). Due to the selective diet of giraffes, competition for available food items can be high. Juvenile giraffes may struggle to mature when they compete with other herbivores (e.g. eland (*Taurotragus oryx*) or kudu (*Tragelaphus strepsiceros*)) for resources at the same height (Deacon, 2015). When selecting a release site, we recommended a diversity of forage plants and low numbers of potential competitors.

5.4 | Water requirements

Giraffes are largely water-independent (Kay, 1997) and are able to extract sufficient water from forage via their digestive system (Clauss, Lechner-Doll, Flach, Tack, & Hatt, 2001). They are capable of surviving in areas with no open water sources, but will utilise water sources when available (Fennessy, 2009; Owen-Smith, 1982). Waterholes play an important role in regulating animal behaviour and may influence giraffe herd distribution (Deacon & Smit, 2017; de Leeuw et al., 2001), which could be considered when predicting habitat use of translocated giraffes. We recommend that any release site includes easy water access uninhibited by the presence of livestock, as giraffes may avoid water points where livestock is present (de Leeuw et al., 2001).

5.5 | Predation risk

The presence of predators is an important consideration when translocating giraffe populations (Muller, 2018). The main predators of giraffes are lions (*Panthera leo*), but also hyaenas (*Hyaenidae* spp.) and leopards (*Panthera pardus*) (Dagg, 2014; Hirst, 1969; Pienaar & De, 1969; Strauss & Packer, 2013). Predators mainly target giraffe calves, but also kill adults (Foster & Dagg, 1972; Leuthold & Leuthold, 1978; Pellew, 1983a). Perceived predation risk and high levels of stress have been shown to reduce reproduction rates in prey species (Zanette, White, Allen, & Clinchy, 2011), and the social networks of giraffes are more fragmented in areas with high predator density and disturbance by humans (Muller, Cantor, et al., 2018). We recommend giraffes not be translocated to areas with high densities of predators.

5.6 | Disease and parasites

Little is known about the influence of diseases and parasites on giraffe behaviour or survival (Dagg, 2014; Lee & Bond, 2016; Muneza et al., 2016). There is some evidence to suggest that pathogen transmission networks are associated with patterns of social interaction in giraffes (VanderWaal, Atwill, Isbell, & McCowan, 2014), indicating that knowledge of disease and parasite load should be a consideration on the health of founder and recipient populations of translocated animals. This is especially important since translocations increase the risk of disease outbreaks in the translocated and recipient populations (Kock, Woodford, & Rossiter, 2010). Disease risk analyses should be used to assess the probability of a disease occurring in association with a translocation and the likely effects of disease (Dalziel, Sainsbury, McInnes, Jakob-Hoff, & Ewen, 2017). Parasite control should only be implemented when the infestation is very high and could be administered during capture and confinement to prevent transfer of parasites to the recipient populations (Bothma, 2002; Malan, Horak, Vos, & Wyk, 1997).

6 | IMPLEMENTATION OF THE TRANSLOCATION

For giraffes, a major challenge is the provision of suitable and safe transport for fully-grown adults, which are 4.0–5.5 m tall and can weigh up to 1,900 kg (Estes, 1991). The decision about which animals to translocate should consider which animals can be most safely and effectively transported. Thus, for giraffes, individuals below the age of 2 years old are often selected. Due to their smaller size, they are easier to load and less susceptible to overhead dangers during transport. Younger animals also have greater reproductive value to help rapidly increase the translocated population. However, 2-year-old juveniles have been observed still suckling from their mother (Z. Muller, personal observation). Although giraffes of this age are no longer solely nutritionally dependent upon their mother's milk, the continuing mother-calf bond may confer survival benefits (Royle, Smiseth, & Kölliker, 2012; Silk et al., 2003, 2009). Translocation of young animals without their mothers may interrupt learning of necessary survival skills. Near-adults (≈4 years) are more likely to have matured sufficiently to cope without the continued presence or influence of their mothers, and males may be in their natural natal dispersal phase and thereby predisposed to adapt to new environments (Stamps & Swaisgood, 2007).

6.1 | Capture

Successful capture is dependent on careful planning, accounting for terrain (e.g. steep slopes, water, and fences), weather, capture methods and equipment (Bothma, 2002). Immobilisation poses risks to both the giraffe and people (Bush, Grobler, & Raath, 2002; Jolly, 2003; Vogelnest & Ralph, 1997). Minimising stress during capture, transportation and release is critical (Calenge, Maillard, Invernia, & Gaudin, 2005; Laubscher, Pitts, Raath, & Hoffman, 2015; Parker et al., 2012; Teixeira et al., 2007). Handling of immobilised animals should be under the expert care of an experienced wildlife veterinarian (IUCN, 2013) or capture team manager.

Giraffes have a high mortality rate during capture (>10%), which makes some veterinarians hesitant to anesthetise them. When applied correctly, chemical immobilisation is safe and effective and is the preferred method of giraffe capture (Hirst, 1966; Morkel, 1993; Swan, 1993). Giraffe have thick skins and dart needles need to be at least 40-mm long. Nonchemical techniques are also available, see Cousins, Sadler, and Evans (2008) for full discussion. Experts in animal capture and translocation should always be consulted.

Giraffe's unique anatomy and size pose practical and handling problems: they are at particular risk of subluxation of cervical vertebrae during the capture operation. The large respiratory dead space adds a physiological disadvantage to safe anaesthesia administration (Bush et al., 2002; Morkel, 1993). Another risk period is the time after immobilisation with opioid drugs, during which the animal will become oblivious to obstacles and may run into dangerous terrain if not managed by an experienced ground support team (Bush et al., 2002; Morkel, 1993).

During immobilisation, the shortest possible knockdown time is critical, using a very high dosage of opioid, reversed immediately when the animal is down before hypoxia can take effect. Darts placed into the shoulder muscles provide quicker knockdown times than those placed in the rump (Langman, 1973a). When immobilised, the head and neck should be held higher than the chest to avoid fatal aspiration pneumonia; the head should be held upright on a slight stretched out posture and should be kept stable to monitor breathing via the nostrils and vital signs using oxygen levels, heartrate and reflex reactions (Figure 1) (Deacon, 2015; Langman, 1973a). The mouth should be lower than the rest of the head so that any excess saliva can drain away, as the animal cannot swallow when it is immobilised. When it is hot, shade should be provided, and water should be applied to the body to keep the animal cool (Hirst, 1966). Giraffes do not close their eyes and cannot blink when they are immobilised; so, a soft blindfold should be placed over their eyes to prevent damage and prevent the eyes from drying out. Using a blindfold during capture also reduces struggle and can reduce the animal's heart rate (Bush et al., 2002). Immobilised animals can still hear, so make as little noise as possible to reduce stress (Langman, 1973a). Following capture, giraffes should be transported from the site of capture to a holding area or boma to recover (Figure 2).

FIGURE 1 An immobilised giraffe, illustrating use of a soft blindfold and elevation of the neck and head on a purpose-built board. In this picture, the mouth of the giraffe is positioned higher as his head, in an ideal situation the mouth must be held lower than the rest of the head. That way any excess saliva can drain away

FIGURE 2 Example of a well-ventilated, purposely built crate for the transport of giraffes in South Africa. The individual pictured is young male, just under the age of 2 years

6.2 | Transportation to release habitat

Animals should only be transported by qualified personnel in possession of valid transport, export, import, or game trader permits as determined by the relevant authorities (for example, SABS, 2000). Transport routes should be scouted in advance for hazards and potential blockages. If a transport route includes overhanging obstructions, a leading vehicle with an indicator pole the same height as the transport vehicle/giraffes should alert the transport vehicle of potential hazards.

Purpose-built, well-ventilated crates should be used with a good gripping surface on the floor (SABS, 2000) (Figure 3). The recommended floor space per adult giraffe is 2.40 m^2 when loaded into a mass crate and transported over short distances (Bothma, 2002). Sliding doors are better than fixed-hinged doors because fixed-hinge doors can cause safety risks to humans if kicked or pushed against by giraffes. During transport, the animals should be inspected constantly or regularly to ensure their safety and wellbeing. Inspection holes should be positioned in such a way that the animals can be inspected without being disturbed or alarmed.

Animals immobilised with long-lasting drugs should not be mixed with individuals that have been given a shorter-acting drug, nor with individuals where the drug is already out of their system. A short-acting tranquiliser is recommended for transporting giraffes that have been recently captured (Ebedes, 1993) to relieve stress and reduce aggression.

6.3 | Release strategy

There are two methods of release: hard release and soft release (de Milliano, Stefano, Courtney, Temple-Smith, & Coulson, 2016). In hard release, animals are set free upon arrival directly into their new environment. Soft release involves the provision of support such as supplementary feeding, provision of shelter or temporary holding areas (Figures 4 and 5) during the initial release phase (Fennessy et al.,

FIGURE 3 A large game capture team is needed to capture giraffes for translocation. A wildlife veterinarian is an essential part of any capture team, and it is advised that the team comprises professionals who are experienced in game capture techniques, due to the difficulties associated with capturing giraffes safely

2019; de Milliano et al., 2016). Temporary holding facilities (Figures 1 and 2) and supplementary feeding at the release site allow released animals time to recover from the stress of travel, acclimatise to the new area and to unfamiliar conspecifics with which they may have been translocated. This potentially reduces the likelihood of long-distance movements away from the release-site; however, holding wild-caught animals in enclosures may also increase stress (Le Gouar, Mihoub, & Sarrazin, 2012; Letty et al., 2007; Stamps & Swaisgood, 2007). Giraffe translocations utilise both hard and soft release, with mixed success (Chege, 2008; Flanagan et al., 2016; Malyjurkova et al., 2014; Nesbit Evans, 1970). There is no information available for which technique is most effective for giraffes, in terms of either reduction of stress during the time of release, or long-term success of the translocation. Increased reporting of translocation outcomes and research work focused on stress hormone analyses associated with different methods of transport and release would be beneficial to inform future translocations. It is also likely that the type of release is dependent upon local circumstances, which should be considered for future research.

Giraffes should not be released in the dark or near a river, dam, lake or fence. The ramp should be at the same height as the truck floor, and the offloading process should be done as quietly as possible. If the giraffes can leave the crate on their own, it should be done as calmly as possible, to try and avoid any injuries occurring during the release.

6.4 | Season

The seasonal timing of translocations is important to ensure adequate nutritional and dietary resources are available for population establishment (Letty et al., 2007; Wacher & Robinson, 2008). It is best to release individuals when food availability is close to its maximum which allows for individuals to adapt to their new environment and increase body mass before food availability decreases (Bright & Morris, 1994; Morris, 2011). Giraffe mortality rates increase with capturing at high ambient temperatures, so translocations should be conducted during seasons and times of day when temperatures are cool.

7 | MONITORING AND CONTINUING MANAGEMENT

Pre- and postrelease monitoring of giraffes and vegetation is essential to evaluate the short- and long-term success of translocations, to provide information for adaptive management of the translocated population and to improve the success of future translocations

FIGURE 4 A wooden holding area, or ‘boma’, measured approximately 100 metres x 75 metres and was used to successfully and securely hold four giraffes for three weeks post capture in East Africa as part of a soft release into this private conservancy in Kenya

FIGURE 5 Example of a giraffe holding area constructed with canvas and steel wires in Kenya. Eight giraffes were securely and successfully held in this holding pen for a period of three weeks, prior to being translocated to a new area to establish a new population

(Fischer & Lindenmayer, 2000; Nichols & Armstrong, 2012; Seddon et al., 2007). Monitoring activities should include regular population assessments to estimate population vital rates of both source and translocated populations (Lee & Strauss, 2016), and monitoring of animal health, movements and social groupings to further understand population growth or decline (IUCN, 2013). The use of monitoring, formal and transparent decision-making processes and data-driven adaptive management will generate the necessary data to make informed management decisions in the future (Regan et al., 2005).

An essential part of translocation planning is assessing, the expected influence of giraffe introduction on the release site and monitoring ecological consequences. Problems such as over-utilisation can be eliminated if the potential intensity and frequency of foraging is considered beforehand. Ongoing vegetation monitoring is critical to understand how translocated animals adapt to their new environments and identify the effects of their browsing within the new area. Habitat assessments may be needed to evaluate resource availability and use.

Nutritional status is crucial for animal productivity, survival and fertility (Wrench, Meissner, & Grant, 1997). One way of measuring whether the nutritional requirements are being supplied is by measuring the nitrogen levels in faeces (Leslie, Bowyer, & Jenks, 2008). Faecal nitrogen concentration is a noninvasive, inexpensive indicator of diet quality of ungulates (Buys, 1990; Erasmus, Penzhorn, & Fairall, 1978; Grant, Meissner, & Schultheiss, 1995; Wrench et al., 1997). In certain areas and at certain times of the year, shortages occur, with nitrogen being the most limiting nutrient (Van Soest, 1994; Wrench et al., 1997). Faecal samples may also be used to assess giraffe parasite load. Further, giraffe body condition should be monitored visually (Jeugd & Prins, 2000; Potter & Clauss, 2005).

8 | FUTURE RESEARCH AND RECOMMENDATIONS

Translocation events are under-reported (but see Flanagan et al., 2016; Van Houtan, Halley, Aarde, & Pimm, 2009), so to improve future outcomes it is critical that all translocation efforts and outcomes, including planning documents, population monitoring and vegetation assessments are fully documented in a publicly available format (Parker, Ewen, Seddon, & Armstrong, 2013; Parlato & Armstrong, 2013). PVAs should be used to inform translocation planning and mitigate the effects of inbreeding depression (Lee et al., 2019). The complex nature of giraffe social organisation is an area which needs further research in the context of translocation events. Studies examining stress indicators during translocation under different techniques such as hard and soft releases would be highly valuable in evaluating techniques. Nutritional studies that include foliage quality and soil properties should be incorporated in future studies. We encourage wildlife managers to adopt a scientific approach to giraffe translocations and advocate that all outcomes—whether successful or otherwise—should be documented and made publicly available to increase understanding and develop best practice.

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CONFLICT OF INTEREST

The authors have no conflicts of interest.

DATA AVAILABILITY STATEMENT

Not applicable, this is a review of existing literature and personal experience.

ORCID

Zoe Muller https://orcid.org/0000-0002-7238-6702
Derek E. Lee https://orcid.org/0000-0002-1042-9543
Ciska P. J. Scheijen https://orcid.org/0000-0003-0938-8235

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