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ORIGINAL RESEARCH

Promoting rhinoceros welfare during transit: veterinarians' perspectives on transportation practices

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Despite translocation being a useful conservation strategy in rhinoceros management, morbidities and mortalities occurring during transportation pose a significant concern to rhinoceros managers, veterinarians, and scientists.

The objectives of this study were to better understand the effects of transport on rhinoceros and to gain insights from veterinarians involved in rhinoceros translocations about current practices and potential interventions that could improve welfare.

A weblink and QR code to an online questionnaire with a total of 46 questions in Google Forms was sent to veterinarians who had experience in African rhinoceros transportation, through personal emails and social network forums.

Results demonstrated that despite dehydration and negative energy balance being reported as the major causes of morbidities and mortalities during transport and post-release, most veterinarians (30/35; 86%) involved in rhinoceros translocation did not offer water, parenteral fluids, or feed to transported animals, for logistical reasons and the knowledge or perception of rhinoceros' resistance to taking *ad lib* food and water during transport. However, 52% (15/29) and 41% (15/34) of participants suggested that parenteral fluids could be used as an intervention to mitigate dehydration and negative energy balance respectively. To reduce stress, 94% (33/35) of respondents suggested the use of tranquilisers and sedatives.

This study is the first to systematically investigate and report on practices by veterinarians involved in rhinoceros translocations globally. The study highlights that further research is required to explore optimal and pragmatic techniques in the field to mitigate reported welfare challenges in rhinoceros during transport.

Keywords: rhinoceros, welfare, transport, survey, veterinarian

Introduction

Translocation represents a key practice for the management and protection of rhinoceros (Dickens et al. 2010). The outcomes of rhinoceros translocations are geared towards enhancing the survival of the species by ensuring that individuals survive transport and the post-release phase, settle quickly, and reproduce successfully. All rhinoceros, except for especially well-habituated animals, need to be tranquilised during transport (Morkel & Kennedy-Benson 2007). Means of transport can be by trucks, ship or aircraft including aeroplanes and helicopters (Emslie et al. 2009; Lekolool 2012).

Both black and white rhinoceros are translocated, but there are some species differences that should be kept in mind during immobilisation, transport and release. Both species are aggressive and potentially dangerous when approached on the ground, and have poor eyesight but excellent senses of smell and hearing (Emslie et al. 2009; Morkel & Kennedy-Benson 2007). White rhinoceros are more sensitive to the effects of immobilising drugs (especially opioids) compared to black rhinoceros. When confined in a transport crate, unlike white rhinoceros, black rhinoceros display aggressive behaviour that can sometimes lead to self-inflicted wounds. Black rhinoceros habituate quicker to bomas (two to three days) and start feeding and drinking early on, while adaptation for white rhinoceros can take up to 12 days (Kenya Wildlife Service 2018). Black rhinoceros are browsers and their preferred habitat is dense vegetation which makes immobilisation difficult. White rhinoceros, on the other hand, are grazers and inhabit relatively open areas, making capture easier (Emslie et al. 2009; Morkel & Kennedy-Benson 2007; Kock & Burroughs 2014). The different feeding niches of the two species must also be considered when trying to feed animals in bomas and crates, and when determining their site of release.

Generally, rhinoceros are neither offered water nor feed during translocations as they are usually reluctant to drink and eat because of the effects of tranquilisers, fear of transportation and not being accustomed to drinking and feeding from troughs and the confines of the transport crates (Morkel & Kennedy-Benson 2007). However, dehydration and negative energy balance were recently identified as among the main welfare challenges to black and white rhinoceros during transportation over 16 hours (Pohlin et al. 2020).

To better understand the effects of transport on rhinoceros and to gain insights from veterinarians involved in rhinoceros translocations globally, we conducted an online survey.

Methods and design

The questionnaire and the administration thereof were approved by the University of Pretoria's Faculty of Veterinary Science

Research Ethics Committee and Faculty of Humanities Ethics Committee (REC043-20), and reporting followed the guidelines outlined by the Checklist for Reporting Results of Internet E-Surveys (CHERRIES) (Eysenbach 2004). The questionnaire was developed by all authors of this paper and underwent several iterations before being uploaded as a Google Form (https://forms.gle/7vKUhwLrmbfFCesj6). The functionality of the online questionnaire was then tested by the study team, and necessary adjustments were made as recommended (Ball 2019). Access to the questionnaire was granted to participants via a weblink and QR code, and any person with the link could access and voluntarily complete the survey. There were no incentives for completing the survey. The survey was open for participation from March to May 2023.

The target population for this survey were mostly local wildlife and zoo veterinarians who had experience in African rhinoceros transportation. Relevant individuals and interest groups were pre-identified by the authors and were contacted through personal email, personal WhatsApp accounts and a Telegram group named the Wildlife Vet Group. This South African-based Telegram group has more than 300 members and is administered by a South African wildlife veterinarian, with the objective of sharing wildlife knowledge gained over the years in an easy, open, and accessible platform to any veterinarian in the world.

A consent form for the survey was developed in accordance with University of Pretoria guidelines and was included as the first page of the survey. The consent form explained the objectives of the study and how to correctly answer the questions. This form also assured the participants that their identities would remain anonymous outside of the study team, and that the study had been approved by multiple ethics committees of the University of Pretoria. Participants consented through their participation in the survey.

The questionnaire consisted of four parts with a total of 46 questions:

Part 1: Sociodemographic information including information about the participant's geographical location and educational background (questions 1 and 2).

Part 2: Rhinoceros translocation experience including questions on species and numbers of rhinoceros transported, frequency and causes of morbidities and mortalities encountered during and after transport (questions 3–18).

Part 3: Interventions during transport including questions on administration of sedatives/tranquilisers and provision of drinking water and feed during transport (questions 19–37).

Part 4: Opinions on management of stress, dehydration, and negative energy balance during transport. This part sought to gain insights on how participants thought it would be best to reduce stress and improve the welfare of rhinoceros during transport (questions 38–46).

The questions required either a selection of one or more answers from a list of options, numeric answers, or comments. Several adaptive questions were included, where certain follow-up questions were conditional on the response to a previous question. Participants could move backwards and change answers to previous questions. Users had to provide their name and email address, and this information was used to ensure that no duplicate items from the same user were included.

Responses were automatically saved via the Google Form platform and data was downloaded as a CSV file which was opened in Microsoft Excel. Due to the nature of our study, statistical analyses were not attempted. Data were analysed descriptively and presented in terms of graphs, tables and percentages depending on the nature of the response. Graphs were constructed by using GraphPad Prism version 10 (GraphPad Software, Boston, Massachusetts USA).

Results

A total of 35 respondents completed the survey. The majority (31/35; 89%) of responses were received from Africa, including Botswana, Kenya, Namibia, South Africa, Swaziland, Tanzania, Uganda, and Zambia. Four of the 35 veterinarians (11%) were practising in Europe (all in Hungary).

Just over a third (13/35, 37%) of respondents had only a veterinary science degree (Bachelor of Veterinary Science or equivalent), 46% (16/35) had an additional Masters-level degree, 14% (5/35) had a PhD, and one participant had a certificate in wildlife capture and relocation.

Fifty-seven per cent (20/35) of respondents reported experience in translocating both white and black rhinoceros, whereas 31% (11/35) and 12% (4/35) had experience in translocation of only white or black rhinoceros respectively. Therefore, a total of 31 respondents had experience with white rhinoceros transport and 24 respondents had experience with black rhinoceros transport. The total number of rhinoceros transported by individuals ranged from one to 9 025 with an average of 501 rhinoceros per respondent throughout their practising period.

Thirty-four participants provided feedback regarding the longest duration of transport. Sixty-five per cent (22/34) of these respondents reported to have translocated animals for more than 16 hours and the remainder (12/34; 35%) reported to have translocated rhinoceros for less than 16 hours. The calculated average transport time of all reported translocations from this survey is 32.5 hours with the longest transport period being 168 hours. In addition, 35 participants provided a response regarding the means of transport used whereby ground transport was used most often (27/35; 77%) and 23% of respondents stated that they had transported rhinoceros by air (8/35).

In the context of the survey, morbidity was considered as an animal displaying signs not consistent with health, or falling sick or being injured either during capture, transport or within a month of release. Morbidities during transport were reported by most respondents for both species. Of 31 participants with experience in white rhinoceros transport, 64.5% (20/31) and out of 24 participants with experience in black rhinoceros transport, 79% (19/24) reported morbidities, with estimated morbidity rates of 1.2% and 0.2% in white and black rhinoceros respectively. For white rhinoceros, 29% (9/31) of respondents reported that they had experienced morbidities within a month post-release, while 54% (13/24) reported this for black rhinoceros, with post-release

Table I: Causes of morbidity and mortality reported by veterinarians during transport and one-month post-release in white and black rhinoceros. Respondents could select more than one cause.

	Number of responses	
	White rhinoceros	Black rhinoceros
	(*n*)	(*n*)
Respondents with transport experience	31	24
Morbidity during transport		
Dehydration	3	1
Energy deficiency	3	1
Stress	4	5
Trauma	6	8
Cardiomyopathy		1
Adverse drug effects	3	2
Mortalities during transport		
Dehydration	2	
Energy deficiency	3	
Stress	3	4
Trauma	1	2
Infectious disease	1	
Adverse drug effects	1	
Morbidity one-month post-release		
Dehydration	2	4
Energy deficiency	1	2
Stress	3	6
Trauma	3	5
Infectious disease	1	3
Adverse drug effects		1
Maladaptation	1	2
Malnutrition		1
Fighting	2	3
Dystocia	1	
Endoparasites		1
Mortality one-month post-release		
Dehydration	2	6
Energy deficiency	1	2
Stress	3	6
Trauma	3	5
Infectious disease	1	3
Maladaptation	1	2
Fighting	2	1
Dystocia	1	

morbidity rates of 1.9% and 2.2% in white and black rhinoceros respectively.

In the context of the survey, mortality was regarded as the number of animals that died during capture, transport or within a month post-release. Respondents further reported on experience with mortalities during transport and one-month post-release in both species. Mortalities of white rhinoceros

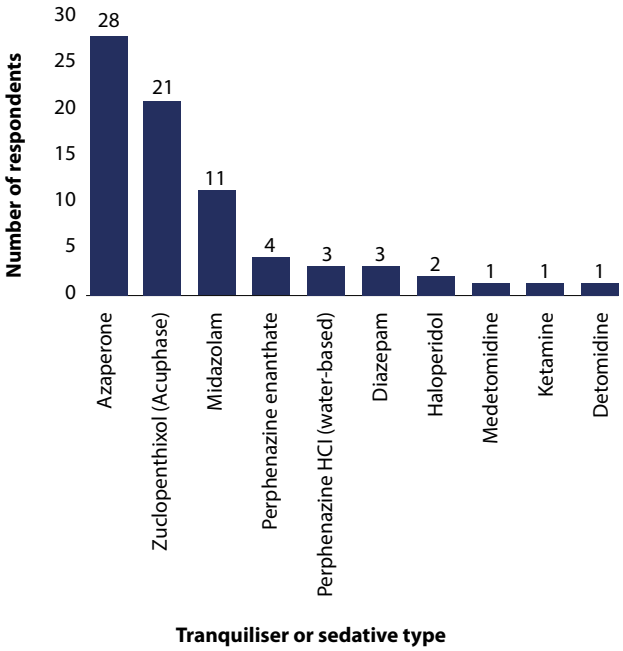

Figure 1: Column chart showing the responses of veterinarians detailing the type of preferred tranquilisers or sedatives used during the transport of rhinoceros.

during transport were reported by 77% (24/31) of respondents and by 96% (23/24) of respondents transporting black rhinoceros, with a mortality rate of 0.1% in both species during transport. Furthermore, mortalities one-month post-release was reported by 81% (25/31) and 67% (16/24) of respondents for white and black rhinoceros respectively. Mortality rates within one-month post-release were reported to be 1% in white and 0.5% in black rhinoceros. Causes for morbidities and mortalities during transport and post-release in both species are detailed in Table I. Not all respondents who indicated that they had experienced morbidity or mortality gave further information as to the causes.

Ninety-four per cent (33/35) of respondents reported using tranquilisers or sedatives during transport. The drugs used by most respondents were azaperone and zuclopenthixol (Figure 1), and of 33 respondents, around half (16/33; 48%) reported that

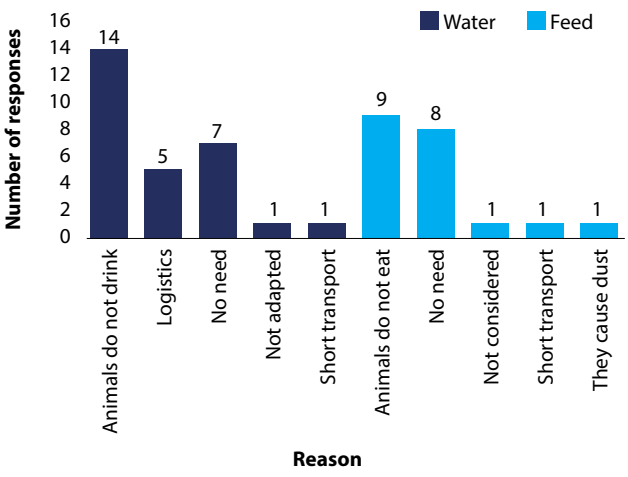

Figure 2: Clustered bar chart showing responses reported by veterinarians on reasons why water and feed are not given to rhinoceros during transport.

Table II: Selected drivers for dehydration and negative energy balance in rhinoceros during transport as reported by veterinarians.

	Number of responses	
Drivers	**Dehydration (*n*)**	**Negative energy balance (*n*)**
Adverse drug effects	7	9
Excessive sweating	15	
Urination	1	
Water deprivation	15	
Food deprivation		12
Advanced pregnancy		1
Poor body condition		2
Stress		1

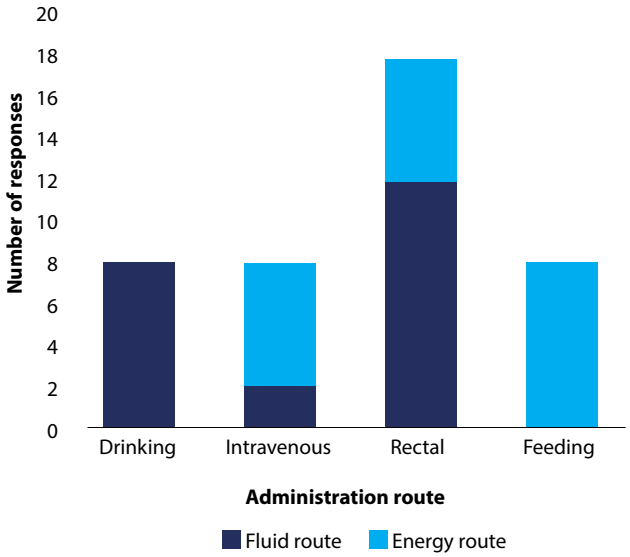

Figure 3: Stacked bars showing the responses for the suggested routes of administration for fluid and energy administration in rhinoceros during transport.

the typical effect observed following the administration of these drugs was mild tranquilisation.

The most reported management system that rhinoceros were kept in prior to transport was free-ranging (21/35; 60%), then boma-adapted (7/35; 20%), and boma-adapted with crate training (7/35; 20%).

Most respondents (30/35; 86%) reported neither providing water nor feed during transport in both white and black rhinoceros. Reasons for not providing water and feed during transport are outlined in Figure 2.

Most respondents stated that dehydration (24/35; 69%) and negative energy balance (21/35; 60%) were challenges affecting the welfare of white and black rhinoceros during transport. Selected drivers resulting in dehydration and negative energy balance in white and black rhinoceros during transports are presented in Table II.

Of 29 respondents, 52% (15/19) suggested the use of parenteral fluids as an intervention during transport that could prevent dehydration. Of 34 respondents, 41% (15/34) suggested parenteral energy supplementation as a worthwhile means to explore to prevent negative energy balance in rhinoceros during transport.

Twenty-three participants replied to the question about the most preferred routes of fluid administration, and 52% of these respondents (12/23) suggested that fluids be administered per rectum. Furthermore, 21 participants replied concerning the most preferred route of energy administration; 38% of these respondents (8/21) suggested feeding to be the most preferred route. Intravenous and per rectum energy supplementation were also suggested as routes of energy administration during transport of white and black rhinoceros by 33% (7/21) and 29% (6/21) of the respondents respectively (Figure 3).

Based on the 35 respondents' experiences 78 suggestions were provided as to the best ways to reduce stressors during rhinoceros translocation. These are collated in Figure 4.

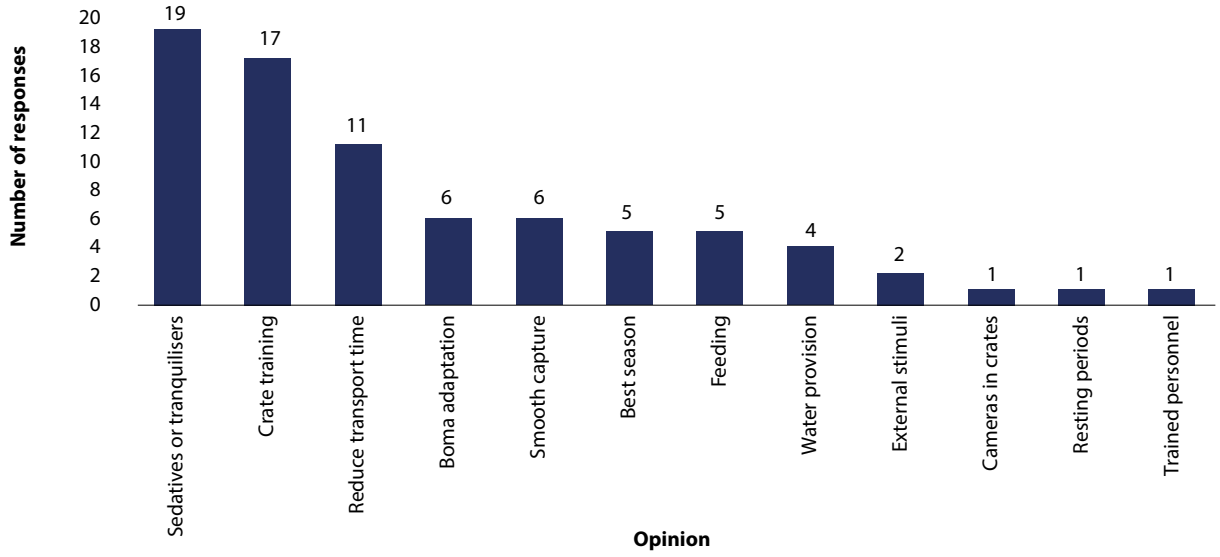

Figure 4: Column chart showing the opinions from veterinarians about the best interventions to reduce stress and improve welfare of rhinoceros during transport.

Discussion

The main finding from our survey demonstrates that despite dehydration and negative energy balance being reported as among major causes of morbidities and mortalities during transport and post-release, most practising veterinarians involved in rhinoceros translocation do not offer water, parenteral fluids, or food to transported animals. The main suggested drivers which cause dehydration and negative energy balance are excessive sweating, water deprivation, food deprivation and possible adverse side effects of the drugs used during transport. The findings partly mirror those of a study conducted recently to assess challenges to animal welfare associated with capture and road transport of rhinoceros, in which the authors identified dehydration, negative energy balance, skeletal muscle fatigue, and stress-induced immunomodulation as major challenges (Pohlin et al. 2020).

Excessive sweating may be related to high ambient temperature. It is advised that rhinoceros capture and translocation should be timed to coincide with the cooler hours of the day to avoid the risk of hyperthermia and other heat-related complications (Emslie et al. 2009). It would also make sense to avoid the hotter summer months, however planning the timing of translocations may not be in the control of the attending veterinarian, and some translocations may take place during inappropriately hot times of the day or year. Most survey participants do not offer water or feed because their experience indicates that rhinoceros simply do not drink or eat while transported. These experiences are supported by a report in a handbook for black rhinoceros translocation which states that non-domestic animals are usually not offered drinking water or feed during translocations because they are often reluctant to drink and eat because of the effects of tranquilisers or sedatives, fear of transportation, not being used to drinking or eating from troughs and being in the confinement of the crates (Morkel & Kennedy-Benson 2007). Moreover, based on the survey results, for most translocations, animals were sourced from a free-ranging management system, with a hard release at their destination after transport. These practices are in contrary to the recommendation given by the African Rhino Specialist Group and other experts that there should be some stages of acclimatisation whenever rhinoceros translocations are conducted, especially for long transportation (Emslie et al. 2009; Morkel & Kennedy-Benson 2007; Rogers 1994). A period of habituation to water, feed troughs and transport crates may mitigate some of the factors proposed to inhibit drinking and eating during transport. The reported lack of acclimatisation and refusal of animals to eat or drink are important as they can be used to advise rhinoceros translocation practitioners on optimal approaches to reduce stress and other welfare challenges when translocating rhinoceros. However, in terms of logistics and cost, particularly for white rhinoceros, field-to-field translocations are more effective and are thought to lead to better post-release adaptation as eating under natural conditions resumes quickly. White rhinoceros may not eat in confinement and often have to be released again. Experience that has been obtained in practice therefore encourages field-to-field translocation, especially if under 24 hours, contrary to published recommendations. Other conditions that are in favour of field-to-field translocation of rhinoceros include but are not limited to: the release site having excellent nutritional conditions, abundance of surface water, release site has similar habitat to capture site, availability of excellent capture unit that can capture and release animals with very little stress and excitement, and the recipient area does not have an established rhinoceros population (Morkel & Kennedy-Benson 2007).

In our study, most veterinarians suggested that fluids be administered parenterally, specifically *per rectum*. The benefits of rectal fluid administration in large animals have been reported. For example, rectal fluid administration (proctoclysis) in healthy, euhydrated horses at 5 mL/kg/h for six hours was comparable to the haemodilution achieved with fluid administration via nasogastric tube (Khan et al. 2019). Rectal fluid administration, using lukewarm tap water, has also been used as supportive therapy of endotheliotropic herpes virus-haemorrhagic disease in elephant calves at a dose of 10 to 20 mL/kg body weight (Dastjerdi et al. 2016).

Stress was also proposed as an important cause of morbidity and mortality in rhinoceros during transportation. However, stress is a non-specific term referring to a response of the body to any demand (Fink 2010). When it comes to assessing stress in wild animals or populations for conservation purposes, it is still not well understood how the acute stress response transitions to, and is affected by, chronic stress (Gormally & Romero 2020). Unfortunately, in our survey we were not able to clarify why the responders believed that stress played a role, and how stress was identified, for example based on behavioural changes indicating distress or based on signs and lesions of chronic stress at post-mortem assessment.

To reduce stress during transport of rhinoceros, findings from this survey indicate that the majority of veterinarians prefer to use tranquilisers and sedatives, with azaperone being the drug of choice. Azaperone is the most used (short-acting) tranquiliser for rhinoceros transport (Portas 2004; Metrione & Eyres 2014). Azaperone is a butyrophenone which provides tranquilisation for two to four hours with an onset of effect within 10 to 20 minutes after intramuscular injection (Portas 2004). The calming effects of azaperone are mediated in the brain by blockade of dopamine receptors in the basal ganglia and limbic system (Wouters et al. 2020; Read & McCorkell 2002), resulting in tranquilisation.

Recently, the use of midazolam (a short-acting benzodiazepine) has been documented for the capture and transportation of rhinoceros, with reported benefits of muscle relaxation, and was used by 11/30 survey participants. Midazolam may have an advantage over azaperone because benzodiazepines are free from undesirable cardiovascular side effects, like hypotension, and have better anxiolytic properties (Pohlin et al. 2020). Apart from the short-acting drugs, zuclopenthixol, a longer-acting tranquiliser, is commonly used during the transport of rhinoceros and was the second most used drug among the survey participants (Pohlin et al. 2020; Rogers 1994; Read & McCorkell 2002; Morkel & Kennedy-Benson 2007). Zuclopenthixol is an oil–based thioxanthine derivative usually administered intramuscularly, causing tranquilisation within an

hour of administration with effects lasting up to three to four days (Reuter & Winterbach 1998; Read & McCorkell 2002).

Although the drugs mentioned are used with the intent of reducing stress in transported animals, a significant number of survey participants had the perception that these drugs contributed to dehydration and negative energy balance (Table II). Additionally, despite the common use of tranquilisers and sedatives to mitigate stress, most respondents still identified stress as a cause of morbidity and mortality. These findings highlight that these drugs are perceived to not be completely effective at mitigating the stress response, that more needs to be done to prevent or reduce stress during transport, and that participants believe that these tranquilisers and sedatives play a role in causing dehydration and negative energy balance. Unfortunately, further information as to which drugs are primarily involved, and possible mechanisms, was not solicited. We are not aware of any direct pharmacological action of the three drugs discussed above on renal, thirst or energy balance. It could be argued that tranquilised and sedated animals will not eat or drink, but since animals were not offered food or water in most cases, this is not a direct explanation. Although the drugs may indeed not be totally effective at reducing stress, inadequate experience and expertise in using these drugs effectively could be a factor. Therefore, at no time should rhinoceros translocations be performed without the availability of an appropriately qualified and experienced veterinarian (Emslie et al. 2009).

Trauma was identified as the major cause of morbidity during transport, and as an important factor that could persist into the post-release phase, leading to morbidity and mortality post-release. Rhinoceros have been observed to frequently traumatise themselves during transport and sometimes die after they have been released (Morkel & Kennedy-Benson 2007; Miller et al. 2016). Black rhinoceros in particular experience the breaking of horns, fracture of nasal bones, bruising and swelling of lips, muscle damage and heat stress (Morkel & Kennedy-Benson 2007). During the transport, animals (particularly large bulls) often have no or little movement due to limited space. This lack of movement increases muscle tone as a result of leaning when trying to maintain postural balance which can potentially lead to poor muscular tissue perfusion, increased muscle cell permeability, and the release of muscle enzymes into the blood stream (Fisher et al. 2009). When clinical chemistry is conducted in transported animals, common findings are an increase in the muscle enzymes creatine kinase, aspartate transaminase, and lactate dehydrogenase, indicating muscle cell damage (Pohlin et al. 2020).

The mortality rate for rhinoceros translocations in South Africa and Namibia has been previously estimated to be 13.4% (Linklater et al. 2011), higher than suggested in our survey. The mortality rate in single translocations can occasionally be as high as 100%, as was the case with a translocation of black rhinoceros in Kenya in 2018 where all 11/11 animals died. The cause of death was ascribed to a "multiple stress syndrome" intensified by salt-water poisoning and complicated by dehydration, starvation, proliferation of opportunistic bacteria in the upper respiratory tract, gastric ulcers and gastritis" (Save the Rhino 2018 & Parliament of Kenya 2019). The reported mortality rates in other studies and reports mentioned above are higher than what has been reported in our study. This disparity is probably because our questionnaire did not confine questions to single translocations, but rather spanned participants' experience over potentially multiple translocations and entire careers, and probably included adverse events that occurred when chemical immobilisation and translocation procedures were less sophisticated than in recent years. Therefore, our findings for mortality and even morbidity rates should be seen as a very rough estimate based on participants' recollections, not on robust data. Morbidity and mortality of rhinoceros during translocations have become a paramount concern amongst veterinarians, rhinoceros managers and scientists (Dickens et al. 2010; Swaisgood 2010; Harrington et al. 2013), and the importance of further investigations of the incidences and causes of morbidity and mortality cannot be overemphasised.

As previously mentioned, habituation to novel elements and stressors before transportation may improve rhinoceros welfare, as was echoed by surveyed veterinarians, most of whom advised crate training before transport be adopted as one of the initiatives to improve the welfare of transported animals, especially if long distance and time will be required. It has also been suggested that if the rhinoceros are to be shipped or flown over long distances, a field to boma phase before translocation is preferred so that animals, while in the bomas, get used to noises, and are trained to drink and eat in a crate (Emslie et al. 2009). In terms of crate training, duration may vary depending on individual rhinoceros temperament, with a suggested range of one to six weeks. Crate training has the added advantage that rhinoceros may not need to be tranquilised in transit (Morkel & Kennedy-Benson 2007; Rogers 1994). Although boma habituation and crate training have proven to be valuable for the translocation of rhinoceros, especially over long distances, this approach is not always feasible for all translocations since it is expensive to undertake, it can cause chronic stress in the animals, failure of animals to adapt to bomas, and in some locations boma facilities and experienced staff are not available. In addition, holding rhinoceros in bomas can expose them to poaching, therefore, it is a security concern as it has been recently observed in Namibia where rhinoceros have been poached in holding bomas (Chapman & White 2021). Therefore, field to field translocation is still common practice and will likely remain so. Particularly, but not exclusively, it is during these translocations that more needs to be explored to address welfare challenges, especially those related to dehydration, negative energy balance and stress.

Most respondents to the survey were from the African continent. This finding is most likely due to the geographic reach of the survey but may also reflect the higher numbers of rhinoceros on the African continent, and that rhinoceros translocations within their natural range have become a common undertaking amongst local rhinoceros conservation and management authorities (Sterk et al. 2023; Knight et al. 2015; Kohi & Lobora 2019; Khayale et al. 2021). We did not survey participants on their years of experience, or type of work. We also did not ask respondents whether morbidities and mortalities of translocated

rhinoceros could have been due to their own lack of knowledge or experience. Although many questions in the survey related to causes of morbidity or mortality had an option for "other" where veterinarians could have listed lack of knowledge, experience, their own stress, or other "human" factors as reasons, no participant took this opportunity. Based on our survey, dehydration and negative energy balance are important causes of translocation failure, but there may be an undocumented element of human error too. Some answers regarding causes of morbidity and mortality put forward by participants may have been based on subjective opinion, rather than evidence-based facts.

Despite CHERRIES (Eysenbach 2004) being consulted during the design of the study, our study did not adhere to every item on the checklist. For example, the completion rate was not calculated because our questionnaire was open and there was no target for the number of responses; instead, we aimed to solicit answers from any veterinarian with a known history of rhinoceros translocation experience. A lack of randomisation of the order of both the questions and the response items within each question to reduce the risk for response biases was another study limitation. Our questions were designed in such a way that the flow of ideas and concepts were interlinked sequentially, therefore it was not possible to randomise items. Some response distributions in our study were skewed towards the first sections of the questionnaire, suggesting that most participants responded enthusiastically to the first parts of the survey and then possibly lost interest towards the end. Another limitation was no initial mechanism to prevent multiple entries from the same individual, although the presence of multiple entries from the same email address could be checked after the survey was complete (there were none). Our study used neither cookies nor a unique identifier such as the IP address of the respondent device. The study relied only on email address and other demographic details of the respondent, making it a challenge to identify any multiple entries from the same respondent operating with different names and email addresses. However, we believed that the motivation to provide multiple entries for this specific study would likely be low.

Furthermore, the answer to the question on numbers of morbidities and mortalities was not mandatory. Therefore, calculations for estimated morbidity and mortality rates are not accurate as we only used the numbers from the respondents who opted to complete that question.

Despite these shortfalls, this study is the first to systematically investigate and report on practices by veterinarians involved in African rhinoceros translocations globally. We recommend further studies be conducted to explore optimal techniques that can be used in the field to mitigate or correct welfare challenges like dehydration, negative energy balance and stress in rhinoceros during transport.

Conclusion

Despite dehydration and negative energy balance being identified as important causes of morbidities and mortalities during transport and post-release, most practising veterinarians involved in rhinoceros translocation do not offer water, parenteral fluids, or food to transported animals due to logistical reasons and because during shorter translocations, wild caught rhinoceros rarely take water and food. Recently, crates have been designed to have a water trough fitted and after 24 hours, animals will have a better chance of drinking, therefore, this challenge for longer translocations can be overcome. Although sedatives and tranquilisers are used with the aim of reducing stress during transport, survey participants are of the opinion that these drugs contribute to dehydration and negative energy balance, and that stress often still plays a role in morbidity and mortality. However, to mitigate welfare challenges, more than half of the respondents recommend exploring the applicability of rectal fluid administration to rhinoceros during transport. The study highlights that further research is required to explore optimal and practical techniques in the field to mitigate reported welfare challenges in rhinoceros during transport.

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Conflict of interests

The authors declare they have no conflicts of interest that are directly or indirectly related to the research.

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Ethical approval

The questionnaire and the administration thereof were approved by the University of Pretoria's Faculty of Veterinary Science Research Ethics Committee and Faculty of Humanities Ethics Committee (REC043-20).

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References

Ball, H.L., 2019, Conducting online surveys, *Journal of Human Lactation* 35(3), 413-417. https://doi.org/10.1177/0890334419848734.

Chapman, L.A., White, P.C., 2021, Patterns in rhino poaching activity on private land in South Africa, *African Journal of Ecology* 59(2), 378-386. https://doi.org/10.1111/aje.12842.

Dastjerdi, A., Seilern-Moy, K., Darpel, K., et al., 2016, Surviving and fatal elephant endotheliotropic herpesvirus-1A infections in juvenile Asian elephants-lessons learned and recommendations on anti-herpesviral therapy, *BMC Veterinary Research* 12(1), 1-11.

Departmental Committee on Environmental and Natural Resources (2019). Report on the inquiry into death of eleven black rhinos after translocation to the Tsavo East National Park sanctuary. Available from: http://www.parliament.go.ke/sites/default/files/2019- 09/REPORT%20ON%20DEATH%20OF%2011%20BLACK%20RHINOS%20AT%20TSAVO%20EAST%20NATIONAL%20PARK_compressed.pdf. Accessed 20 June 2024.

Dickens, M.J., Delehanty, D.J., Romero, L.M., 2010, Stress: an inevitable component of animal translocation, *Biological Conservation* 143(6), 1329-1341. https://doi.org/10.1016/j.biocon.2010.02.032

Emslie, R., Amin, R., Kock, R., 2009, Guidelines for the in-situ re-introduction and translocation of African and Asian rhinoceros, *IUCN* 2009. https://doi.org/10.2305/IUCN.CH.2009.SSC-OP.39.en.

Eysenbach, G., 2004, Improving the quality of Web surveys: the Checklist for Reporting Results of Internet E-Surveys (CHERRIES), *Journal of Medical Internet Research* 6(3), e34. https://doi.org/10.2196/jmir.6.3.e34.

Fink, G., 2010, Stress neuroendocrinology, *In book: Stress: Neuroendocrinology and Neurobiology*. https://doi.org/10.1126/science.1185866.

Fisher, A.D., Colditz, I.G., Lee, C., et al., 2009, The influence of land transport on animal welfare in extensive farming systems, *Journal of Veterinary Behavior* 4(4),157-162. https://doi.org/10.1016/j.jveb.2009.03.002.

Gormally, B.M., Romero, L.M., 2020, What are you actually measuring? A review of techniques that integrate the stress response on distinct timescales, *Functional Ecology* 34(10), 2030-2044. https://doi.org/10.1111/1365-2435.13648.

Harrington, L.A., Moehrenschlager, A., Gelling, M., et al., 2013, Conflicting and complementary ethics of animal welfare considerations in reintroductions, *Conservation Biology* 27(3), 486-500. https://doi.org/10.1111/cobi.12021.

Kenya Wildlife Service, 2018, Immobilization and translocation protocol for black rhinoceros (Diceros bicornis) and white rhinoceros (Ceratotherium simum) in Kenya. Available at: https://www.kws.go.ke/content/guidelines-wildlife-translocation. Accessed 16 September 2024.

Kock, M.D., Meltzer, D., Burroughs, R., 2014, Chemical and physical restraint of wild animals: A training and field manual for African species, 2nd Edition. South African Veterinary Foundation, Pretoria, S. Africa.

Kohi, E.M., Lobora, A.L., 2019, Conservation and management plan for black rhino in Tanzania 2019-2023. Tanzania Wildlife Research Institute (TAWIRI). ISBN 978-9987-9567-6-0.

Khan, A., Hallowell, G., Underwood, C., et al., 2019, Continuous fluid infusion per rectum compared with intravenous and nasogastric fluid administration in horses, *Equine Veterinary Journal* 51(6), 767-773. https://doi.org/10.1111/evj.13113.

Khayale, C., Omondi, P., Kariuki, L., et al., 2021, Kenya's first White Rhino Conservation and Management Action Plan, *Pachyderm* 62, 112-118.

Knight, M., Emslie, R., Smart, R., et al., 2015, Biodiversity management plan for the white rhinoceros (Ceratotherium simum) in South Africa 2015-2020. Department of Environmental Affairs, Pretoria, South Africa.

Lekolool, I., 2012, Mega-translocations: the Kenya Wildlife Service at its best, *The George Wright Forum, JSTOR* 93-99.

Linklater, W.L., Adcock, K., du Preez, P., et al., 2011, Guidelines for large herbivore translocation simplified: black rhinoceros case study, *Journal of Applied Ecology* 48(2), 493-502. https://doi.org/10.1111/j.1365-2664.2011.01960.x.

Metrione, L., Eyres, A., 2014, Rhino husbandry manual. Fort Worth (TX): International Rhino Foundation.

Miller, M., Kruger, M., Kruger, M., et al., 2016, A scoring system to improve decision making and outcomes in the adaptation of recently captured white rhinoceroses (Ceratotherium simum) to captivity, *Journal of Wildlife Diseases* 52(2s), S78-S85. https://doi.org/10.7589/52.2S.S85.

Morkel, P., Kennedy-Benson, A., 2007, Translocating black rhino. Current techniques for capture, transport, boma care, release and post-release monitoring, *Frankfurt Zoological Society*.

Pohlin, F., Hofmeyr, M., Hooijberg, E.H., et al., 2020, Challenges to animal welfare associated with capture and long road transport in boma-adapted black (Diceros bicornis) and semi-captive white (Ceratotherium simum) rhinoceroses, *The Journal of Wildlife Diseases* 56(2), 294-305. https://doi.org/10.7589/2019-02-045.

Pohlin, F., Hooijberg, E.H., Buss, P., et al., 2020, A comparison of hematological, immunological, and stress responses to capture and transport in wild white rhinoceros bulls (Ceratotherium simum simum) supplemented with azaperone or midazolam, *Frontiers in Veterinary Science* 7, 790. https://doi.org/10.3389/fvets.2020.569576.

Portas, T., 2004, A review of drugs and techniques used for sedation and anaesthesia in captive rhinoceros species, *Australian Veterinary Journal* 82(9), 542-549. https://doi.org/10.1111/j.1751-0813.2004.tb11196.x.

Read, M.R., Mccorkell, R.B., 2002, Use of azaperone and zuclopenthixol acetate to facilitate translocation of white-tailed deer (Odocoileus virginianus), *Journal of Zoo and Wildlife Medicine* 163-165. https://doi.org/10.1638/1042-7260(2002)033[0163:UOAAZA]2.0.CO;2.

Reuter, H.-O., Winterbach, H., 1998, Current capture technique and drug dosage regime for the immobilization and tranquilization of free-ranging black rhinoceros (Diceros bicornis bicornis) in Namibia, *Annual Conference-American Association of Zoo Veterinarians* 410-415.

Rogers, P., 1994, Transportation and boma management of rhinos, *Proceeding Symposium Rhinos as game ranch animals, Onderstepoort* 9-10.

Save the Rhino, 2018, News on all the rhinos translocated to Tsavo East National Park have died. Available from: https://www.savetherhino.org/africa/kenya/all-rhinos-translocated-to-tsavo-east-national-park-have died/#:~:text=On%2026%20July%202018%2C%20the,in%20Tsavo%20East%20National%20Park. Accessed 20 June 2024.

Sterk, M., Cubas, F.S., Reinhard, B., et al., 2023, The importance of large pans and surrounding bushveld for black rhino (Diceros bicornis ssp. bicornis) habitat use in the Kalahari: implications for reintroduction and range expansion, *Namibian Journal of Environment* 7, A-13.

Swaisgood, R.R., 2010, The conservation-welfare nexus in reintroduction programmes: a role for sensory ecology, *Animal Welfare* 19(2), 125-137. https://doi.org/10.1017/S096272860000138X.

Wouters, H., Hilmer, S.N., Gnjidic, D., et al., 2020, Long-term exposure to anticholinergic and sedative medications and cognitive and physical function in later life, *The Journals of Gerontology* 75(2), 357-365. https://doi.org/10.1093/gerona/glz019.