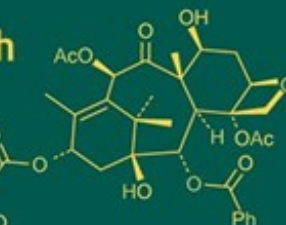


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The names and affiliations of all authors are provided below, following the references.

Long-distance road transportation of albino blackbucks (*Antelope cervicapra*): A case report

MD Pawshe¹, SM Kolangath², SV Upadhye³, AP Gawande⁴, VM Dhoot⁵, BK Bhadane⁶, MS Patil⁷, Shalini AS⁸

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ABSTRACT

Long-distance transportation of captive wild ungulates is a complex welfare-sensitive procedure in which capture, restraint, confinement, vehicle movement, environmental temperature, hydration and journey duration may collectively influence animal health and survival. The challenge is particularly pronounced during summer transportation in India, where prolonged exposure to high ambient temperatures may increase the risk of heat stress and dehydration. The present case report describes the planning, execution and outcome of a 1047-km road transportation of 26 albino blackbuck (*Antelope cervicapra*) from the National Zoological Park, New Delhi, to Balasaheb Thackeray Gorewada International Zoological Park, Nagpur, Maharashtra, India. Prior permission was obtained from the Central Zoo Authority, and a comprehensive transportation plan was developed incorporating experienced animal-handling personnel, veterinary preparedness, vehicle modification, route selection, feeding, watering, thermal management, rest and systematic monitoring. The animals were captured and loaded at the source institution using a boma capture apparatus. A modified Eicher Pro 3018 XP plus was used for transportation, with sharp corners and potentially hazardous projections covered with soft mattresses and the floor provided with sand bedding to minimise traumatic injury and improve footing. The journey, completed in approximately 35 h, was undertaken predominantly during evening and cooler hours, with daytime rest after approximately 11:00 h. The vehicle was maintained at approximately 40 km/h, while sudden braking, rapid acceleration and abrupt manoeuvring were avoided. Water was continuously available, and additional cooling was provided by sprinkling water over the greenery within the transport compartment. Feeding was undertaken after approximately eight hours, followed by rest, while animals were monitored at approximately six-hour intervals. All 26 animals arrived safely at the destination, with 100% survival and no recorded transport-associated mortality, major medical emergency or clinically evident major trauma. The animals remained alert and responsive, with normal feeding behaviour throughout the journey. The successful outcome demonstrates that careful pre-transport planning, experienced capture and loading, vehicle modification, controlled driving, continuous hydration, heat-load mitigation, appropriate rest and regular monitoring can collectively facilitate safe long-distance transportation of blackbuck under challenging summer conditions. This case provides a practical welfare-oriented framework for long-distance inter-zoo transportation of medium-sized ungulates in hot climatic conditions.

Keywords: Albino blackbuck, *Antelope cervicapra*, Wildlife transportation, Zoo animal transport, Animal welfare, Heat stress, Road transportation, Ungulates, Zoological management, India

1. Introduction

Transportation of wild animals is an essential component of modern zoological management and conservation breeding programmes. Movement of animals between zoological institutions may be required for population management, genetic exchange, conservation breeding, and development of viable ex-situ populations, institutional cooperation and maintenance of appropriate demographic structures. Although transportation is routine in zoological practice, it remains one of the periods during which captive wildlife may be exposed to substantial physiological and behavioural stress. Capture, restraint, loading, confinement, vehicle movement, vibration, unfamiliar surroundings, changes in temperature and humidity, altered feeding and watering schedules and prolonged restriction of movement can collectively affect animal welfare during transportation. Stress associated with captivity and transportation may influence both behavioural and physiological responses, and the cumulative effects of multiple stressors may be more important than any single event (Broom, 2005; Minka *et al.*, 2009; Morgan *et al.*, 2007; Moberg *et al.*, 2000) [1, 2, 3, 4].

The Central Zoo Authority, Government of India, has recognised transportation as a critical component of zoo animal management and has developed protocols for the transportation of wild animals [5, 6, 7]. These

Corresponding Author:
SV Upadhye
Wildlife Research &
Training Centre, Gorewada,
Nagpur, Maharashtra, India

protocols emphasise appropriate planning, animal selection, trained personnel, suitable containers and vehicles, veterinary preparedness, adequate ventilation, feeding and watering arrangements, documentation and emergency preparedness [5, 6, 7]. Similar principles have been emphasised internationally, where transportation welfare is considered to depend on the interaction between animal characteristics, handling procedures, vehicle design, environmental conditions and journey duration (Broom, 2005; Knowles, 1998; Cockram, 2007) [1, 8, 9]. Among ungulates, blackbuck (*Antelope cervicapra*) presents particular challenges during capture and transportation. Blackbucks are highly alert, agile and fast-moving antelopes, and sudden stimuli can produce rapid escape responses. During capture, restraint and confinement, uncontrolled movement may increase the risk of collision with enclosure structures or transport equipment. Appropriate handling and reduction of unnecessary stimulation are therefore important components of transportation welfare, particularly in species capable of rapid flight responses (Grandin, 2019; Hosey *et al.*, 2013) [10, 11]. Environmental temperature represents another important determinant of transportation success. This is particularly relevant to long-distance transport in India during May and June, when ambient temperatures may become considerably high across northern and central regions. Thermal stress can be exacerbated by confinement, inadequate ventilation, direct solar exposure and prolonged travel. Animal transportation under challenging environmental conditions therefore requires careful consideration of journey timing, ventilation, hydration, environmental cooling and rest periods (Broom, 2005; Cockram, 2007; Moberg *et al.*, 2000) [1, 9, 4]. The present case documents the long-distance transportation of 26 albino blackbuck from the National Zoological Park, New Delhi, to Balasaheb Thackeray Gorewada International Zoological Park, Nagpur. The journey covered approximately 1047 km and was completed in approximately 35 h. The transportation was undertaken during the hot May–June period and therefore required specific measures for managing environmental heat load. The operation involved advance regulatory permission, preparation of a detailed transportation plan, experienced capture and loading, modification of a Eicher Pro 3018 XP plus vehicle, provision of sand bedding and protective padding, controlled driving, continuous access to water, feeding and rest schedules, environmental cooling, six-hourly monitoring and logistical support through a pilot vehicle. The purpose of this case report is to describe the transportation protocol adopted, document the clinical and behavioural outcome of the animals and identify practical management measures that may have contributed to successful completion of a long-distance journey without mortality or major transport-associated medical emergencies.

2. Methods

2.1 Regulatory permission and transportation planning

Prior to transportation, permission was sought from the Central Zoo Authority for movement of the 26 albino blackbuck from the National Zoological Park, New Delhi, to Balasaheb Thackeray Gorewada International Zoological Park, Nagpur. Following regulatory approval, an operational transportation plan was developed. The planning process included identification of the animals to be transported, arrangement of the transport vehicle, preparation of the transport compartment, selection of the route, identification of animal-handling and veterinary personnel, allocation of drivers, arrangement of feed and water, provision of bedding and protective material, preparation for heat management, scheduling of monitoring, provision of staff requirements and arrangements for emergency situations. The trans-

portation was planned as an integrated animal-welfare operation rather than solely as a logistical movement. This approach was consistent with the CZA protocols for transportation of wild animals, which emphasise that capture, handling, loading, transport and unloading should be considered interconnected stages of a single welfare-sensitive operation [5, 6, 7]. The importance of pre-transport planning and risk reduction has also been highlighted in the broader literature on animal transportation and welfare (Broom, 2005; Knowles, 1998; Cockram, 2007) [1, 8, 9].

2.2 Animals and destination

A total of 26 albino blackbuck (*Antelope cervicapra*) maintained at the National Zoological Park, New Delhi, were selected for transportation to Balasaheb Thackeray Gorewada International Zoological Park, Nagpur. The animals were transported as part of an inter-zoo movement. The receiving institution had arrangements in place for their arrival and subsequent management. The animals were considered suitable for transportation under the institutional veterinary and zoological management procedures. Appropriate animal selection and health assessment prior to movement are recognised as important components of safe transportation because pre-existing illness or injury may increase the risk of adverse outcomes during prolonged travel [5, 6, 1].

2.3 Personnel and logistical organisation

The transportation operation involved animal-handling personnel, veterinary support, drivers and logistical personnel. Two drivers were deployed for the animal transport vehicle to facilitate safe driving over the approximately 35-h journey. This arrangement allowed driving responsibilities to be shared and reduced the requirement for prolonged continuous driving by a single individual. Appropriate management of personnel and clear allocation of responsibilities are important in reducing operational errors during complex animal transport operations [5, 1]. A pilot vehicle accompanied the animal transport vehicle throughout the journey. The pilot vehicle served as an important logistical support unit and assisted in the management of water, feed, food for staff and other requirements. Arrangements for breakfast and lunch for the accompanying personnel were coordinated through the support vehicle. The separation of animal transportation from staff and logistical requirements allowed the animal transport vehicle to remain focused on maintaining the welfare and comfort of the animals.

2.4 Materials and equipment

Prior preparation of all materials was considered essential because interruption of a long-distance animal transport operation can increase both logistical difficulty and animal stress. Adequate preparation of transport facilities, emergency supplies, water, feed and monitoring materials is recommended in both national zoo transportation guidance and the wider animal transportation literature [5, 6, 7, 1]. The materials used or required for the transportation are summarised in Table 1.

The quantities of consumable materials such as water, sand, greenery and feed were determined according to journey duration, vehicle capacity, prevailing environmental conditions and contingency requirements. Provision of adequate reserves of essential supplies is particularly important during long-distance animal transportation because delays, traffic disruptions or vehicle-related events may prolong the journey beyond the planned duration [5, 1, 9].

Table 1. Materials and equipment required for long-distance transportation of 26 albino blackbuck

Sr. No.	Material/equipment	Quantity	Purpose/application
1	Modified Eicher Pro 3018 XP plus animal transport vehicle	1	Primary transportation of 26 blackbuck
2	Pilot/support vehicle	1	Logistical support, water, feed, staff requirements and emergency assistance
3	Soft mattresses/protective padding	As required to cover all exposed corners and projections	Prevention of collision-related injury
4	Clean sand for bedding	Sufficient to provide complete floor coverage	Soft bedding, improved footing and reduction of impact
5	Potable drinking water	Adequate reserve for entire journey	Continuous hydration
6	Water storage containers	As required	Storage and provision of drinking water
7	Water buckets/cans	As required	Watering and environmental cooling
8	Water-spraying equipment	1 set	Sprinkling water over greenery for evaporative cooling
9	Green fodder/greenery	Adequate quantity for journey	Familiar feed and maintenance of a cooler microenvironment
10	Regular animal feed	Sufficient for journey and contingency period	Feeding after scheduled intervals
11	Feeding containers/troughs	As required	Provision of feed
12	BOMA/capture apparatus	1 set	Capture and controlled loading of animals
13	Animal-handling equipment	As required	Safe capture, handling and loading
14	Veterinary first-aid/emergency kit	1 complete kit	Management of unexpected medical emergencies
15	Basic veterinary examination equipment	1 set	Clinical assessment during monitoring
16	Thermometer/environmental monitoring equipment	1 set	Monitoring of thermal conditions
17	Cleaning and sanitation materials	Adequate quantity	Maintenance of hygienic transport conditions
18	Spare sand/bedding material	Adequate reserve	Replacement or replenishment of bedding
19	Communication devices/mobile phones	For all key personnel	Coordination and emergency communication
20	Regulatory and transportation documents	1 complete file	Legal and administrative compliance
21	Emergency contact list	1 set	Communication with veterinary/zoological facilities en route
22	Drinking water and food for staff	Adequate quantity	Staff welfare during long journey
23	Fuel and routine vehicle supplies	Adequate reserve	Uninterrupted transportation
24	Vehicle repair/emergency equipment	1 set	Management of minor vehicle emergencies
25	Lighting/inspection equipment	1 set	Animal observation during evening and night travel
26	Record sheets/documentation material	1 set	Monitoring and journey documentation

2.5 Transport vehicle and modifications

The Eicher Pro 3018 XP plus vehicle was used for transportation of the animals. It is a light commercial vehicle platform available in different wheelbase and body configurations. Published technical specifications for the relevant Eicher Pro 3018 XP plus platform indicate variation in vehicle dimensions according to wheelbase and body configuration [12]. Because internal usable dimensions are more relevant to animal transportation than external vehicle dimensions, the final scientific report should include the exact dimensions of the modified animal compartment based on the vehicle and body-building records. For the present operation, the vehicle was modified specifically to improve animal safety. Sharp corners, exposed projections and potentially hazardous surfaces were covered with soft mattresses. This modification was intended to reduce the possibility of traumatic injury in the event of animals coming into contact with the vehicle structure during acceleration, braking or road irregularities. Prevention of injury caused by inappropriate vehicle design, hard surfaces and sudden movement is an important principle of animal transportation (Broom, 2005; Knowles, 1998; Grandin, 2019) [1, 8, 10]. A layer of sand was provided over the floor as bedding. The sand provided a relatively soft substrate and improved the comfort and stability of the animals compared with an exposed hard surface. Provision

of appropriate flooring and bedding is relevant to animal comfort and welfare because inadequate footing may increase the risk of slipping, instability and injury during transportation (Broom, 2005; Grandin, 2019; Hosey *et al.*, 2013) [1, 10, 11]. Ventilation was maintained throughout the journey. Adequate ventilation is particularly important during prolonged transportation because poor air exchange may contribute to thermal discomfort and deterioration of air quality within the transport environment [5, 1, 9].

2.6 Capture and loading

Capture and loading were undertaken at the National Zoological Park, New Delhi, by personnel experienced in handling zoo animals. A boma apparatus was utilised for capturing and loading the blackbuck into the transport vehicle. Capture was regarded as one of the critical stages of the operation because blackbucks are agile and highly responsive animals. Excessive pursuit, repeated handling or uncontrolled movement can increase the likelihood of injury and stress. The objective was therefore to complete capture and loading in a controlled manner while avoiding unnecessary chasing, prolonged restraint or excessive human disturbance. Minimisation of handling stress and careful management of capture procedures are important principles in the welfare of captive and transported animals (Grandin, 2019; Hosey *et al.*, 2013; Morgan *et al.*, 2007) [10, 11, 3].

The prepared transport vehicle was positioned and made ready before commencement of loading so that the interval between capture and loading could be minimised. The capture and loading operation was completed without a reported major adverse event. Once loaded, the animals were maintained under controlled conditions and the transport vehicle departed according to the predetermined schedule.



Figure 1. Albino blackbuck during the transit



Figure 2. Green Net utilized for the construction of a boma



Figure 3. Creation of the platform and Boma for the unloading of the albino blackbucks.

2.7 Route and travel schedule

The total transportation distance was approximately 1047 km and the NE-4 route was used. The complete journey required approximately 35 h. Journey duration is an important consideration in transportation welfare because prolonged confinement may result in cumulative stress, fatigue and disruption of normal behavioural and physiological patterns (Broom, 2005; Knowles, 1998; Cockram, 2007) [1, 8, 9].

The timing of transportation was deliberately structured around environmental temperature. Major movement was undertaken during evening and cooler hours. After approximately 11:00 h, prolonged transportation during the hottest portion of the day was avoided and rest was provided. This scheduling was particularly important because the journey occurred during May–June, when high environmental

temperatures may increase the risk of thermal stress. Consideration of environmental conditions and journey timing is recognised as an important component of animal transport planning (Broom, 2005; Cockram, 2007; Moberg *et al.*, 2000) [1, 9, 4].

The vehicle was operated at approximately 40 km/h. sudden braking was avoided, as were rapid acceleration, abrupt manoeuvres and unnecessary changes in speed. Smooth vehicle movement was considered important for maintaining animal stability and reducing the possibility of collisions or falls within the transport compartment. Vehicle movement and acceleration forces are recognised contributors to transport stress and injury risk, particularly when animals are unable to maintain stable posture during travel (Broom, 2005; Knowles, 1998; Grandin, 2019) [1, 8, 10].

2.8 Feeding, watering and rest

The animals were provided with water throughout the journey. Continuous availability of water was considered particularly important because transportation was undertaken during the hot summer months. Adequate hydration is a fundamental component of transportation welfare, especially when animals may be exposed to prolonged travel and increased environmental temperatures [5, 1, 9]. Feeding was undertaken after approximately eight hours of transportation, followed by a period of rest. Feed was provided in a manner consistent with the animals' established husbandry routine, and unnecessary dietary changes were avoided. Maintenance of familiar husbandry conditions and minimisation of abrupt changes in feeding management are important considerations for captive animal welfare [5, 11]. Rest periods were incorporated into the transportation schedule. During the hotter part of the day, the vehicle was not continuously driven for prolonged periods. The combination of rest, ventilation, hydration and reduced exposure to peak daytime heat was intended to minimise cumulative transport stress.

2.9 Thermal management and ventilation

Heat management was a major consideration throughout the transportation because the operation was undertaken during May–June. Environmental heat can act as an important stressor, particularly when animals are confined during prolonged transportation (Broom, 2005; Cockram, 2007; Moberg *et al.*, 2000) [1, 9, 4]. The primary strategy was to reduce exposure to peak environmental temperatures by undertaking major travel during evening and night hours and providing rest during the hottest part of the day. Drinking water was available at all times. In addition, water was sprinkled over the greenery provided inside the transport compartment. This intervention was intended to promote evaporative cooling and maintain a relatively cooler microenvironment. The greenery also provided familiar material associated with feeding and husbandry. Ventilation was maintained throughout the journey to facilitate heat dissipation and adequate air exchange. These measures were implemented together because thermal welfare during transport is dependent on multiple interacting factors, including ambient temperature, airflow, confinement, duration of travel and the animals' ability to dissipate heat (Broom, 2005; Cockram, 2007; Moberg *et al.*, 2000) [1, 9, 4].

2.10 Monitoring and assessment

The animals were monitored approximately every six hours during transportation. Monitoring was based primarily on direct observation of behavioural and clinical indicators. Alertness, responsiveness, posture, movement, feeding behaviour, water consumption and general condition were assessed. The animals were also observed for evidence of trauma, excessive agitation, respiratory difficulty, weakness, collapse, dehydration or other abnormalities. Behavioural observation provides an important practical method for assessing animal welfare during transport, particularly when repeated invasive examination may itself increase stress (Hosey *et al.*, 2013; Morgan *et al.*, 2007) [11, 3]. Monitoring was therefore performed while avoiding unnecessary disturbance. The intention was to obtain regular information regarding animal condition without repeatedly handling or exciting the animals.

The animals were transported directly to Balasaheb Thackeray Gorewada International Zoological Park, Nagpur. On arrival, unloading was performed in a controlled manner and the animals were transferred to the designated facility. The animals were observed after arrival for general condition, alertness, responsiveness, feeding behaviour and evidence of trauma or dehydration. The outcome of the transportation was assessed primarily on the basis of survival, absence of major medical emergencies and general behavioural and clinical condition.

The transportation of all 26 albino blackbuck was successfully completed. The animals travelled approximately 1047 km from the National Zoological Park, New Delhi, to Balasaheb Thackeray Gorewada International Zoological Park, Nagpur, over approximately 35 h using the NE-4 route. All 26 animals reached the destination alive, representing a transport survival rate of 100%. No mortality was recorded during the journey and no major medical emergency requiring emergency intervention was observed. The animals remained alert and responsive during transportation. Normal feeding behaviour was maintained, and the animals did not demonstrate any obvious prolonged anorexia associated with the journey.

provision of soft protective mattresses over sharp corners and projections and the use of sand bedding provided a protected transport environment designed to minimise the risk of mechanical injury. The animals were monitored at approximately six-hour intervals. Observations remained satisfactory throughout the journey, with the animals maintaining alertness and awareness of their surroundings. Water remained available throughout the transportation. The use of water sprinkling over the greenery, together with ventilation and travel during cooler hours, was incorporated specifically to address the potential thermal stress associated with transportation during May–June.

The vehicle was operated at approximately 40 km/h and sudden braking was avoided. The controlled driving strategy allowed the animals to remain stable within the transport compartment. The planned daytime rest period after approximately 11:00 h further reduced exposure to peak environmental heat. The capture and loading process at the National Zoological Park was completed without any reported major adverse event. The use of the boma capture apparatus by experienced animal-handling personnel allowed the animals to be captured and loaded in an organised manner. The pilot vehicle provided logistical support throughout the journey. Water, animal feed and food requirements for accompanying staff could be managed through the support system. Two drivers were deployed for the main transport vehicle, permitting the long journey to be undertaken without requiring a single driver to remain continuously responsible for driving.

Table 2. Summary of the transportation operation and outcome

307

4. Discussion

The present case demonstrates the successful long-distance transportation of 26 albino blackbuck over approximately 1047 km without mortality or recorded major medical emergency. The journey was undertaken during May–June, making thermal management an important component of the operation. The successful outcome was likely attributable not to any single intervention but to the cumulative effect of advance planning, appropriate animal handling, vehicle preparation, controlled driving, hydration, heat management, rest, monitoring and logistical coordination. Transportation is widely recognised as a potentially stressful event for captive wildlife. Stress can arise during capture and restraint before transportation even begins and may subsequently be compounded by confinement, vehicle vibration, unfamiliar surroundings, noise, altered environmental conditions and changes in routine (Broom, 2005; Morgan *et al.*, 2007; Moberg *et al.*, 2000) [1, 3, 4]. Animal welfare during transport is therefore best understood as the combined effect of multiple physical, physiological and behavioural challenges rather than a single stressor (Broom, 2005; Knowles, 1998; Cockram, 2007) [1, 8, 9]. The CZA transportation protocols emphasise the importance of trained personnel, appropriate equipment, proper loading and unloading, ventilation, feeding and watering, veterinary preparedness and emergency planning [5, 6, 7]. The present operation incorporated these principles through a structured transportation plan developed before capture and movement.

One of the most important aspects of the operation was the preparation of the transport vehicle. Commercial transport vehicles are not inherently designed for the transportation of live wild ungulates. Exposed corners, metal projections and hard flooring may become sources of injury when animals are subjected to repeated acceleration, braking and vibration. In the present case, sharp corners and potentially hazardous projections were covered with soft mattresses. Sand was placed over the floor to provide bedding and improve comfort and footing. Appropriate flooring and the prevention of injuries associated with transport structures are important elements of animal welfare during transportation (Broom, 2005; Knowles, 1998; Grandin, 2019) [1, 8, 10].

The choice of Eicher Pro 3018 XP plus provided a transport platform suitable for the planned operation. Published dimensions of the Eicher Pro 3018 XP plus vary according to configuration, and therefore the precise vehicle specification should be included in the final manuscript based on the vehicle documentation [12]. From a scientific reporting perspective, internal usable floor area, compartment height, ventilation openings and the actual configuration of the animal compartment would be more informative than external vehicle dimensions alone. Future transportation reports should therefore document these parameters systematically. The capture and loading phase represented another important risk period. Blackbucks are highly alert and agile antelopes, and sudden escape responses can result in collision injuries. The use of an experienced capture team and BOA/capture apparatus allowed capture and loading to be conducted in a controlled manner. An important advantage of having the vehicle prepared before capture was that the interval between capture and confinement could be reduced. Minimising the duration and intensity of handling is considered important in reducing stress responses in captive and transported animals (Grandin, 2019; Hosey *et al.*, 2013; Morgan *et al.*, 2007) [10, 11, 3].

The route and temporal scheduling of the journey were also important. Although the total distance was approximately 1047 km, the journey was completed in approximately 35 h rather than attempting to maximise speed. The vehicle was operated at approximately 40 km/h and sudden braking was avoided. This approach prioritised vehicle stability over rapid completion of the journey. Vehicle movement, acceleration and braking can affect animals' ability to maintain balance and stable posture during transportation (Broom, 2005; Knowles, 1998; Grandin, 2019) [1, 8, 10]. For ungulates, repeated instability may increase the risk of fatigue and traumatic injury. The decision to conduct major transportation during evening and night hours was particularly appropriate given the summer conditions.

Environmental temperature is a major determinant of thermal load during animal transport, and the risk is amplified when animals are confined within a transport compartment (Broom, 2005; Cockram, 2007; Moberg *et al.*, 2000) [1, 9, 4]. After approximately 11:00 h, rest was provided rather than maintaining prolonged movement through the hottest part of the day. The animals were therefore exposed to relatively lower thermal loads during the principal periods of movement. Hydration represented another important component of the transport protocol. Water was made continuously available throughout the journey. This is particularly important when transporting animals during hot weather because water requirements may increase with thermal load. In addition to drinking water, water was sprinkled over the greenery inside the transport compartment. This measure was intended to promote evaporative cooling and create a cooler local environment. The combination of hydration, ventilation, environmental cooling and movement during cooler hours represented a multifactorial approach to heat-stress management. The use of greenery within the compartment may also have contributed to environmental familiarity and maintenance of feeding behaviour. Environmental conditions and husbandry practices that reduce novelty and maintain elements of the animals' normal routine may contribute positively to welfare during stressful events (Hosey *et al.*, 2013; Shepherdson *et al.*, 1998) [11, 13]. The animals maintained normal feeding behaviour in the present case, suggesting that transportation did not result in clinically apparent prolonged disruption of feeding.

The feeding schedule was structured around approximately eight-hour intervals, after which feeding was undertaken and a rest period provided. Maintaining the established type of feed is generally preferable to introducing unfamiliar food during stressful events because abrupt alterations in routine may further affect animal welfare [5, 11]. The observed maintenance of normal feeding behaviour was therefore considered a favourable indicator of adaptation to the transport conditions. Regular monitoring at approximately six-hour intervals provided an opportunity to identify emerging problems without causing continuous human disturbance. Behavioural observation is particularly useful in zoo animal management because changes in alertness, posture, locomotion, respiration, feeding and drinking may provide early evidence of compromised welfare or disease (Hosey *et al.*, 2013; Morgan *et al.*, 2007) [11, 3]. In the present case, the animals remained alert and responsive, and no major abnormality was observed. The absence of mortality among all 26 animals is an important outcome. A mortality rate of 0% does not, by itself, establish that the animals experienced no physiological stress, because stress responses may occur without overt clinical signs (Morgan *et al.*, 2007; Palme, 2019; Moberg *et al.*, 2000) [3, 14, 4]. Physiological measures such as glucocorticoid assessment, body temperature, heart rate variability, haematological parameters and other validated biomarkers could provide a more objective assessment of transport-associated stress (Palme, 2019; Moberg *et al.*, 2000) [14, 4]. Nevertheless, the absence of death, major trauma, collapse, severe respiratory distress or other medical emergency, together with maintenance of normal feeding behaviour and alertness, indicates a favourable clinical and behavioural outcome. The logistical structure of the operation was another important factor. Two drivers were deployed for the main vehicle, while a pilot vehicle accompanied the transport. This provided a degree of operational redundancy and ensured that the animal transport vehicle did not have to carry every logistical responsibility. The pilot vehicle could facilitate access to water, feed, staff meals and other supplies. During long-distance transportation, appropriate planning and availability of sufficient resources are important because unexpected delays can extend journey duration and potentially compromise welfare [5, 1, 9].

The present case demonstrates that transportation success is best understood as a systems-level outcome. The favourable result cannot be attributed exclusively to the modified vehicle, the capture technique, the route or heat management. Rather, these measures interacted. Safe capture reduced the risk at the beginning of the journey; protective padding and sand bedding reduced the potential for mechanical in

jury; controlled driving reduced vehicle-induced instability; evening travel reduced thermal exposure; continuous water availability supported hydration; water sprinkling and ventilation reduced heat load; scheduled feeding and rest supported normal husbandry; and six-hourly monitoring allowed the animal-care team to identify potential problems. This integrated approach is consistent with contemporary approaches to animal welfare, in which welfare outcomes are influenced by multiple interacting physical, behavioural and environmental domains (Fraser, 2008; Mellor *et al.*, 2020) [15, 16].

This approach is particularly relevant to transportation in India, where long road distances and seasonal extremes can create substantial challenges. The present journey was undertaken during a period characterised by high summer temperatures, making the decision to avoid prolonged travel during the hottest portion of the day particularly relevant. Similar strategies may be applicable to transportation of other medium-sized ungulates, provided that species-specific behavioural, nutritional and environmental requirements are considered. The case also highlights several areas that could be improved in future transportation documentation. Although behavioural and clinical observations were recorded, objective physiological measurements were not incorporated. Future studies could obtain baseline measurements before loading and repeat measurements immediately after arrival and during the post-transport acclimatisation period. Non-invasive glucocorticoid monitoring may provide an additional approach for evaluating stress while reducing the need for repeated invasive sampling (Palme, 2019) [14]. Environmental temperature and relative humidity should ideally be recorded at regular intervals inside and outside the transport compartment. Global positioning system-based recording of vehicle speed, duration of stops and route characteristics could further strengthen scientific assessment of transport conditions.

Individual animal identification and pre- and post-transport body weights would also improve assessment of transportation effects. Similarly, systematic scoring of behaviour, posture, respiratory rate and hydration status could permit quantitative comparison between different transport operations. Such information would be particularly valuable for developing evidence-based transport protocols for blackbuck and other antelope species. Another consideration is the distinction between external vehicle dimensions and actual animal-compartment dimensions. Commercial vehicle specifications provide overall dimensions, but welfare assessment requires information about usable floor area, internal height, ventilation area and the arrangement of animals. Therefore, future transportation reports should include a schematic of the transport compartment and its exact dimensions. This would make the protocol more reproducible for other zoological institutions.

The present report is a descriptive case report and has inherent limitations. There was no control group, no alternative transportation method was evaluated and no physiological stress biomarkers were measured. The observations therefore cannot establish that the interventions independently prevented stress or mortality. In addition, the precise contribution of each component of the protocol cannot be quantified. Nevertheless, the successful movement of 26 animals over more than 1000 km without mortality provides useful practical information for zoo and wildlife managers.

From an animal-welfare perspective, the most important lesson from the present transportation is that preparation should begin well before the animals enter the vehicle. Regulatory permissions, personnel, capture equipment, vehicle modifications, bedding, water, feed, emergency equipment, route planning and staff logistics should all be arranged in advance. During hot weather, the journey should be scheduled to minimise exposure to peak temperatures. The vehicle should be driven conservatively, and monitoring should continue throughout the journey rather than being restricted to departure and arrival. These principles are consistent with established guidance on zoo animal management, transportation welfare and contemporary frameworks for assessing animal welfare [5, 6, 7, 1, 15, 16].

5. Conclusion

Successful long-distance transportation of blackbuck requires meticulous planning, appropriate handling and continuous welfare monitoring. Vehicle modification, secure bedding, controlled driving and experienced personnel helped minimise transport-associated risks. Night-time travel, hydration, thermal management and scheduled rest were particularly important under hot climatic conditions. All 26 blackbuck completed the 1047-km journey safely, with 100% survival and no recorded major medical emergency. This case demonstrates the feasibility of welfare-oriented long-distance inter-zoo transport of blackbuck under challenging environmental conditions.

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Authors

MD Pawshe

Wildlife Research & Training Centre, Gorewada, Nagpur, Maharashtra, India

SM Kolangath

Wildlife Research & Training Centre, Gorewada, Nagpur, Maharashtra, India

SV Upadhye

Wildlife Research & Training Centre, Gorewada, Nagpur, Maharashtra, India

AP Gawande

Wildlife Research & Training Centre, Gorewada, Nagpur, Maharashtra, India

VM Dhoot

Wildlife Research & Training Centre, Gorewada, Nagpur, Maharashtra, India

BK Bhadane

Wildlife Research & Training Centre, Gorewada, Nagpur, Maharashtra, India

MS Patil

Wildlife Research & Training Centre, Gorewada, Nagpur, Maharashtra, India

Shalini AS

Wildlife Research & Training Centre, Gorewada, Nagpur, Maharashtra, India