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Reintroduction of the Siberian musk deer (*Moschus moschiferus* Linnaeus, 1758) in Central Mongolia: First practical experiences

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ABSTRACT. The Siberian musk deer (*Moschus moschiferus* Linnaeus, 1758), a small and elusive forest ungulate of northern Asia, has experienced significant population declines in Mongolia driven by habitat degradation, unsustainable pine nut harvesting, and intensive poaching. To support population recovery, the Ministry of Environment and Climate Change of Mongolia, in partnership with the United Nations Development Programme (UNDP), implemented a conservation translocation program over three winter field seasons from 2020 to 2025. Fifteen individuals were captured in the Khan-undur Mountains, an area with stable musk deer occurrence, using coordinated drive-net techniques and transported approximately 130 km to the Bukhun Shar Mountains in the Khangai region.

At the release site, the animals were housed in semi-natural acclimatization enclosures designed to simulate natural forest habitat. Individuals received supplemental hay, lichens, and water and were monitored daily throughout winter to evaluate health, behavior, and adaptation prior to soft release in early spring. All capture, transport, and holding procedures were completed without mortality, demonstrating the feasibility, safety, and welfare compatibility of these methods under field conditions.

This initiative represents the first formally documented reintroduction of *M. moschiferus* in Central Mongolia. The experience gained provides practical guidance for future conservation translocations of small forest ungulates in continental climates. The integrated protocol drive-net capture, same-day short-distance transport, and soft release following prolonged acclimatization offers a realistic framework for similar efforts. Overall, the results underscore the importance of careful source-site selection, pre-release acclimatization, and structured post-release monitoring to improve long-term conservation outcomes for the Siberian musk deer.

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Реинтродукция сибирской кабарги (*Moschus moschiferus* Linnaeus, 1758) в Центральной Монголии: первые практические результаты

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РЕЗЮМЕ. Сибирская кабарга (*Moschus moschiferus* Linnaeus, 1758) в последние десятилетия значительно сократила численность в Монголии из-за деградации местообитаний, неустойчивого сбора кедровых орехов и браконьерства. В 2020–2025 гг. Министерство окружающей среды и изменения климата Монголии совместно с ПРООН реализовало первую в стране программу реинтродукции вида. Пятнадцать особей были отловлены загонно-сетевым методом в горах Хан-Ундур и транспортированы примерно на 130 км в горы Бухун-Шар. Все операции по отлову и перевозке прошли без гибели животных.

После короткой реабилитации особи содержались в полунатуральных акклиматизационных вольерах в течение зимы. Животные демонстрировали стабильное кормовое поведение и спокойную двигательную активность. Мягкий выпуск ранней весной обеспечил выраженную территориальную привязанность: большинство особей в первые недели отмечались в пределах 1–2 км от места выпуска.

Полученные данные подтверждают, что сочетание загонно-сетевого отлова, кратковременной транспортировки и зимней акклиматизации является осуществимым и гуманным подходом для переселения мелких лесных копытных в резко континентальных условиях. Представленный опыт служит практической основой для дальнейших программ восстановления популяции *M. moschiferus* в Монголии.

КЛЮЧЕВЫЕ СЛОВА: транслокация диких животных; загонные сети; акклиматизация; мягкий выпуск; мониторинг после выпуска.

Introduction

Capturing and handling wild animals is a fundamental component of wildlife research and conservation. Safe and efficient capture techniques allow scientists to collect essential biological data, apply identification markers, and conduct various management or conservation interventions (Schemnitz *et al.*, 2009). At the same time, minimizing stress and ensuring animal welfare are core requirements of ethical conservation practice (Kirkwood, 2013). International experience has demonstrated that poorly designed capture protocols may lead to injury, mortality, or behavioral changes, thereby compromising both animal welfare and conservation outcomes (Arnemo & Kreeger, 2018). Consequently, the development and refinement of species-specific capture and handling methods have become cornerstones of reintroduction biology and conservation translocation programs worldwide (Kirkwood, 2013; Brichieri-Colombi & Moehrenschlager, 2016; Seddon *et al.*, 2007; Fischer & Lindenmayer, 2000).

These considerations are particularly relevant for the Siberian musk deer (*Moschus moschiferus* Linnaeus, 1758 (hereafter SMD)), a small and highly elusive ungulate inhabiting the taiga forests of northern and central Asia. In Russia, long-term field studies have contributed significantly to musk deer conservation planning. Notably, researchers from the Severtsov Institute have developed live-capture and telemetry methods to study free-ranging musk deer in the Russian Far East (Maksimova *et al.*, 2014). These studies emphasize the importance of low-stress handling techniques and continuous monitoring as cornerstones of effective conservation translocation strategies (Prihodko, 2021). The species is extremely vigilant and sensitive to disturbance, making capture and translocation challenging. SMD is currently listed as Vulnerable on the IUCN Red List (IUCN, 2015). Males possess elongated upper canines and a musk gland located in a sac beneath the abdominal skin but lack antlers. Because the musk gland is highly valued in traditional medicine and perfumery, males are especially targeted by poachers (Yi *et al.*, 2020). In addition, habitat degradation caused by unsustainable Siberian pine nut harvesting and logging has intensified pressure on remaining populations, and the species may soon be reclassified as Endangered (Zhang *et al.*, 2022).The presence of the SMD in Mongolia was first documented in the mid-19th century, with early surveys in the 1940s providing the first descriptions of its distribution and ecology (Bannikov, 1954). Early research established baseline information on the species' range and habitat associations, highlighting its occurrence in the Khangai and Khentii mountain systems. Later studies expanded this knowledge by examining patterns of distribution, estimating population densities, and assessing conservation needs. These investigations also provided theoretical and practical recommendations for the management of taiga ungulates and introduced methods for evaluating home range, seasonal movements, and demographic structure (Namnandorj, 1957; Davaa, 1963, 1966; Shagdarsuren, 1969, 1974; Damdin, 1989). Collectively, this body of work laid the foundation for understanding the ecology and conservation requirements of SMD in Mongolia.

Historical population estimates underscore the severity of the species' decline. In 1970, Mongolia's SMD population was estimated at 60000–80000 individuals, with densities ranging from 21–35 per 1000 ha in Khentii and 6–8 per 1000 ha in Khangai (Dulamtseren, 1977). By 1986, the Institute of Biology of the Mongolian Academy of Sciences recorded 44000 individuals across 63 soums in six provinces (Dulamtseren, 1989). However, by the early 2000s, densities had dropped to 1.9 per 1000 ha, and the total estimated population was just 6525 individuals (Tsendjav, 2000, 2008). These long-term trends demonstrate not only the species' precarious status but also the urgent need for targeted conservation interventions.

In response, the Ministry of Environment and Climate Change of Mongolia, in collaboration with the United Nations Development Programme (UNDP), initiated the project Ensuring Sustainability and Resilience of Green Landscapes in Mongolia (ENSURE). Within this framework, a SMD reintroduction program aimed to restore local populations within their historical range. The donor site was located in the Khan-Undur Mountains, characterized by mixed larch-pine forests and stable SMD presence. The recipient site, the Bukhun Shar Mountains in the central Khangai range, was selected for its suitable forest cover, low poaching pressure, and potential to support a new population.

This article presents the methodologies and experiences gained from this operation, focusing on practical aspects of capture, translocation, acclimatization, and release during the field reintroduction of SMD in central Mongolia. As the first officially documented reintroduction of the SMD in the country, this initiative represents an important milestone for ungulate conservation in Central Asia and provides a foundation for future reintroduction efforts.

Material and methods

Study area

Selection of donor and reintroduction sites followed the key principles of reintroduction biology, emphasizing ecological similarity between source and release areas, minimal human disturbance, and sufficient habitat connectivity (Kirkwood, 2013). The SMD prefers steep, rugged terrain with dense understory cover, especially in winter when it relies on arboreal lichens and requires secure refuges from predators (Green, 1987). These conditions were characteristic of both donor and recipient sites (Fig. 1).

Khangai Mountains National Park (Donor Site). The source population of SMD was in the Khan-Undur range within Khangai Mountains National Park. This protected area spans approximately 8885 km^2 across Arkhangai, Uvurkhangai, and Bayankhongor provinces in central Mongolia. The park encompasses the headwaters of the Orkhon River and represents a transitional zone between boreal forest and steppe ecosystems. Elevations range from ~1500 m to 3900 m. The climate is strongly continental, with mean monthly temperatures ranging from –12°C in January to 22°C in July. Annual precipitation peaks in midsummer, reaching about 90 mm in July, with most rainfall concentrated between June and August (Supplementary Fig. S1). The mosaic of taiga forest, alpine meadows, and rocky outcrops supports a diverse fauna, including Siberian wapiti (*Cervus canadensis sibiricus* Erxleben, 1777, formerly *C. elaphus sibiricus*), Siberian roe deer (*Capreolus pygargus* Pallas, 1771), wild boar (*Sus scrofa* Linnaeus, 1758), Siberian marmot (*Marmota sibirica* Radde, 1862), snow leopard (*Panthera uncia* Schreber, 1775), and SMD. Human population density is low, and livestock grazing is the primary land use. Ecological surveys have confirmed the park's importance as a stronghold for forest-dwelling ungulates due

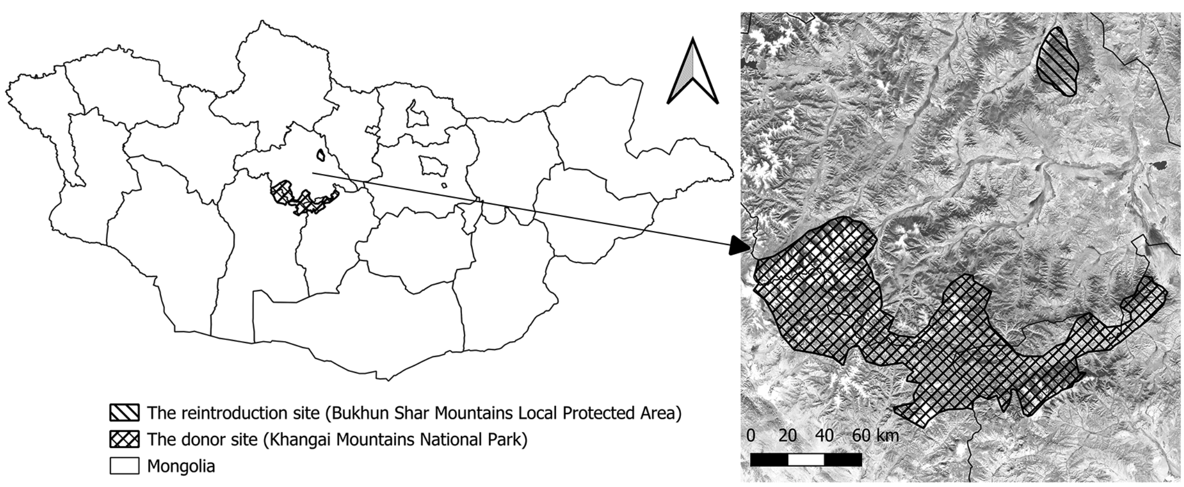

Fig. 1. Map of Mongolia showing the study area in Arkhangai Province. The donor site (Khangai Mountains National Park) is shown with a cross-hatched pattern, whereas the reintroduction site (Bukhun Shar Mountains Local Protected Area) is depicted with a diagonal hatched pattern.

to its well-preserved montane habitat and minimal human disturbance (Clark *et al.*, 2006; Batsaikhan *et al.*, 2014).

Bukhun Shar Mountain Local protected area (Reintroduction Site). Bukhun Shar Mountains, a locally protected area of approximately 350 km² within the districts of Bat-Ulzii, Ulziit, Khayrkhan, and Erdenemandal in Arkhangai Province. As part of the outer ranges of the Khangai Mountains, most peaks lie below 2500 m a.s.l. The region experiences a harsh continental climate similar to that of the donor site, but with slightly warmer and wetter summers. Mean monthly temperatures rise to 23°C in July, and precipitation exceeds 110 mm during the same month, making total summer rainfall higher than in the donor site (Supplementary Fig. S1). Vegetation consists of mixed *Larix sibirica* Ledebour, 1833 and *Betula platyphylla* Sukaczev, 1911 forests interspersed with meadows, scree slopes, and cliffs, providing abundant forage and cover for SMD while limiting access to predators (Dulamsuren, Hauck & Mühlenberg, 2005). Seasonal livestock grazing and pine nut collection occur in parts of the region, but at relatively low intensity compared to other forested areas in central Mongolia (Bukhun Shar Protected Area Administration, 2020).

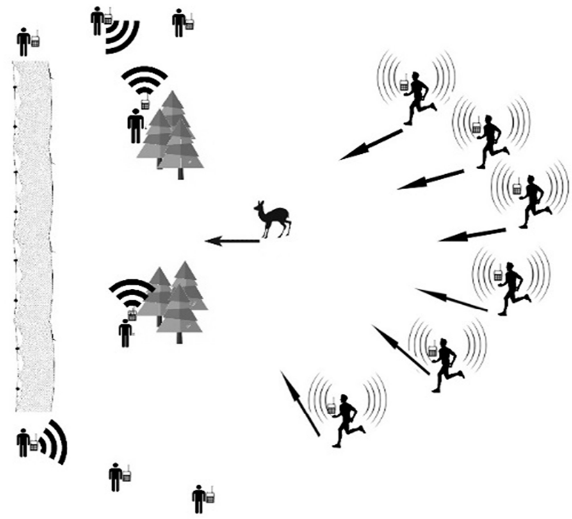

Fig. 2. Schematic overview of a drive-net capture operation for Siberian musk deer. The figure illustrates the coordinated roles of drivers and net handlers, the positioning of nets along movement corridors, and the typical sequence leading to safely securing an animal.

Capture methods

Fieldwork was conducted during three late-autumn expeditions (December 2020, November–December 2022, and November–December 2024). Each expedition involved 20–25 team members, including wildlife biologists from the Institute of Biology, Mongolian Academy of Sciences, faculty and students from the National University of Mongolia, and local wildlife rangers. All participants underwent structured pre-fieldwork training on wildlife capture ethics, chemical immobilization, emergency first aid, and radio communication protocols. Training followed the Government of the Northwest Territories' Wildlife Care Committee Standard Operating Procedures, emphasizing animal welfare and assigning high-skill procedures (e.g., collaring) to experienced personnel (Cattet, 2011; Kreeger & Arnemo, 2018).

Target capture sites were selected through snow tracking, camera-trap surveys, and interviews with local herders. Three core trapping areas — Ogtor, Buural and Zurkh in the Khan-Undur range — were identified based on consistent SMD activity. Drive-net enclosures (2–3 per site) were positioned in valleys and along ridgelines within movement corridors. Nets were constructed of soft nylon mesh (300–400 m length, 1.5–2 m height) supported by removable poles camouflaged with local vegetation. Access routes were cleared of obstacles such as rocks and fallen logs to minimize injury risk. Capture operations were restricted to ambient temperatures between –20°C and –5°C in accordance with established cervid live-capture recommendations (Schemnitz *et al.*, 2009).

To ensure efficiency and coordination, capture operations followed a standardized protocol. Prior to each drive-net attempt, the team was divided into two sub-groups, with each member carrying a short-wave radio. One sub-group (6–8 people) acted as drivers responsible for gently pushing deer toward the nets, while the other sub-group (6–8 people) remained concealed near the net site to secure animals once entangled.

The drive sequence began with the driving team splitting into 2–3 units on foot to search for fresh tracks in newly fallen snow. Once fresh tracks were located, an experienced tracker followed them to visually confirm the presence of a SMD. Upon sighting, the tracker relayed the animal's position and movement direction to all team members. Meanwhile, the net team quietly set up nets in the anticipated escape direction, taking care to minimize noise and disturbance. Nets were deployed within 2–5 minutes and held in place by designated handlers. When both the net team and drivers reported readiness, the team leader gave the command to initiate the drive. The drivers then formed a loose semicircle around the deer, gradually closing in and guiding the animal toward the nets. During this phase, the drivers moved slowly and quietly, producing only minimal sounds (e.g., branches snapping, footsteps in snow) to gently encourage forward movement while avoiding panic or excessive stress. Drives typically covered distances of 1.5–4.5 km, depending on terrain and the initial distance between the deer and the nets (Fig. 2).

Once the deer approached within ~300 m of the nets, the drivers simultaneously produced loud noises to startle the animal into running directly toward the enclosure. If driven too calmly, deer occasionally detected and avoided the nets by retreating or circling around them. When an individual became entangled, the net team immediately emerged from concealment to secure the animal. Handlers first covered the eyes with a cloth hood to reduce stress, then positioned the animal in sternal recumbency before disentangling limbs and transferring it quickly into a ventilated transport crate (Supplementary Fig. S2).

Across all three seasons, 38 drive-net attempts resulted in the successful capture of 15 individuals. No mortalities occurred during capture or immediate post-release, and only minor superficial abrasions were observed. Nets were cut immediately if animals showed excessive stress; this occurred in 1–2 cases, consistent with best-practice recommendations that individuals displaying undue stress be released promptly (Quicksilver Air Inc, 2005). The observed sex ratio was 2:1 (♀:♂).

Handling and animal care during capture

During restraint, handlers monitored posture, respiration, and overall behavior to prevent overexertion and stress. Animals were placed on insulating mats to avoid hypothermia and handled for less than 20 minutes whenever possible. Morphometric data such as body length, hind foot length, and upper canine length were recorded when safe to do so. Fecal pellets and hair samples were collected opportunistically for future genetic and hormonal analyses (Supplementary Fig. S3). No immobilization drugs were used during this operation; all handling relied on physical restraint and rapid release protocols to minimize physiological impact.

Transport and acclimatization

Each captured individual was placed in a ventilated wooden transport crate (100 × 50 × 75 cm) lined with straw for insulation (Supplementary Fig. S4). Crates were designed to limit excessive movement while allowing sufficient airflow. From the Khan-Undur capture sites, animals were transported approximately 130 km to the Bukhun Shar Mountains using small trucks. Transport was completed on the same day of capture and lasted 2–3 hours. Animals were monitored continuously for posture, calmness, and respiration throughout transit.

Upon arrival at the reintroduction site, individuals were transferred to semi-natural acclimatization pens established within forest habitat near the release area. These facilities were designed to provide a safe, quiet environment for recovery from capture and transportation stress and to allow gradual adaptation to local climatic and ecological conditions. During the acclimatization period, deer were regularly supplied with hay, lichens, mosses, and water, and were checked daily by rangers and biologists to monitor feeding activity, health, and general behavior. The detailed structure, feeding management, and seasonal maintenance of these enclosures are described in the following section.

The use of acclimatization facilities is widely recognized as a best practice to enhance survival and site fidelity in reintroduced ungulates (Kirkwood, 2013; Bubac *et al.*, 2019; Thévenin, 2019).

Acclimatization enclosures and management

After transportation to the reintroduction site, all captured SMD were transferred into semi-natural acclimatization enclosures for a defined adaptation period. This stage aimed to facilitate recovery from capture and transport stress, restore normal physiological functions, and allow gradual adjustment to local climatic and ecological conditions. Each individual was kept under observation for 7–10 days before entering the main acclimatization phase, which lasted from December to April.

A total of five enclosures (100 m × 100 m each) were established in a mixed *Larix sibirica–Betula platyphylla* forest near the release zone. The enclosures were surrounded by nylon mesh fencing reinforced with wooden posts. Inside, natural shrubs and tree trunks were retained to provide shade and cover, and artificial hiding shelters and elevated resting platforms were added to enhance comfort. Feeders and water containers were positioned several meters from the fences to minimize human scent and disturbance. The overall design replicated natural forest habitat while ensuring safety and ease of daily monitoring (Supplementary Fig. S5).

Throughout the winter acclimatization period, the deer were fed daily with a mixture of hay, dried lichens (*Usnea longissima, Bryoria* spp.), and moss collected from the donor site. Each individual received approximately 0.7–1.2 kg of hay and 0.3–0.5 kg of lichens per day, supplemented with snow or water for hydration. Feeding activity was closely monitored as an indicator of health and adaptation. Uneaten food was replaced daily, and the amount of feed adjusted according to consumption. Water and snow were refreshed regularly to maintain hygiene.

Feeding was conducted quietly during late afternoon hours to align with the natural crepuscular rhythm of the species. Handlers observed each individual's appetite, posture, and activity daily to evaluate its physical condition. Any signs of distress — such as restlessness, repeated pacing, or reduced feeding — were immediately recorded, and human presence was minimized around the pens. The same caretakers attended the animals throughout the season, wearing neutral clothing and maintaining consistent routines to reduce stress stimuli.

To prevent social isolation, the enclosures were arranged so that individuals could maintain visual and olfactory contact, allowing limited communication through scent and soft vocalizations. This spatial arrangement reduced anxiety and facilitated social stabilization before release. Where strong mutual affinity was observed between individuals, adjacent compartments were reorganized to maintain proximity while avoiding potential aggression.

The acclimatization phase also incorporated gradual exposure to local environmental conditions. Deer were allowed to experience ambient temperature fluctuations, natural sounds, and forest scents to promote spatial orientation and habitat familiarity. This three- to four-month holding period enabled animals to establish behavioral routines and spatial memory suited to the release environment.

Daily monitoring confirmed that the deer adapted well to the enclosures, exhibiting calm behavior, normal feeding patterns, and no aggressive interactions. The acclimatization process proved essential for minimizing stress and improving post-release survival prospects.

Release and post-release monitoring

Following a 3–4-month acclimatization period, SMD were released during calm daylight conditions in early spring. Releases were conducted quietly without direct human interference at the exit points to minimize stress. Each individual exited the pen independently and moved into adjacent natural cover. Post-release monitoring relied on visual observations, track surveys, and ranger patrol reports. Observers recorded direct sightings, feeding signs, and tracks near the release area to confirm activity and survival. Several individuals were repeatedly observed within 1–2 km of the release pens during the first weeks after liberation, indicating successful acclimatization and site retention. Detailed results of post-release survival and site fidelity observations are presented in the Results section.

Results

Capture outcomes

A total of 38 drive-net operations were conducted across three field seasons, resulting in the successful capture and translocation of 15 SMD (Table 1). This corresponds to an overall capture success rate of 39.5% (15 / 38). Capture efficiency varied slightly among years: two deer in 2020 (1 ♂, 1 ♀), seven in 2022 (2 ♂, 5 ♀), and six in 2024 (2 ♂, 4 ♀).

Table 1. Individual data of *Moschus moschiferus* reintroduced in central Mongolia (2020–2025).

ID	Year	Capture site	Sex	Age class
1	2020	Buural	♂	Adult
2	2020	Ogtor	♀	Adult
3	2022	Buural	♂	Adult
4	2022	Buural	♀	Adult
5	2022	Buural	♀	Juvenile
6	2022	Ogtor	♀	Adult
7	2022	Ogtor	♀	Adult
8	2022	Buural	♂	Adult
9	2024	Buural	♀	Juvenile
10	2024	Buural	♀	Adult
11	2024	Zurkh	♂	Adult
12	2024	Zurkh	♀	Adult
13	2024	Zurkh	♂	Adult
14	2024	Zurkh	♀	Adult
15	2024	Buural	♀	Juvenile

In total, five males and ten females were captured, giving an overall sex ratio of (2.0 ♀ : 1 ♂), which did not differ significantly from a 1 : 1 distribution ($\chi^2 = 1.67$, $p > 0.05$). The higher proportion of females likely reflects sex-related behavioral differences, as females tend to remain longer in favorable habitats and are less prone to flight during drive operations. Most individuals were adults (12 adults, 3 juveniles), indicating that mature animals predominated among the captured group. Spatially, captures were concentrated in three mountain blocks within the Khan-Undur range: Buural and Ogtor (2020–2022) and Zurkh (2024).

No mortalities or severe injuries occurred during capture. Only two individuals (13.3%) showed minor superficial abrasions on the limbs, which healed naturally without medical intervention. Capture conditions were generally calm, and no cases of exhaustion or myopathy were observed. Overall, each successful capture required an average of 2.5 drive-net attempts.

Handling and animal condition during capture

All SMD were physically restrained without the use of chemical immobilization. Average handling time per individual was 16.4 ± 4.2 minutes (range 10–22 min). Animals remained alert but not aggressive after hooding, and respiration, posture, and temperature remained within normal limits. None showed abnormal recovery behaviors after release into transport crates.

Basic morphometric measurements were obtained from 12 individuals, with adult body mass averaging 10.9 ± 1.1 kg, hind-foot length 31.6 ± 1.2 cm, and upper-canine length in males 6.3 ± 0.5 cm. All animals exhibited good body condition, with palpable fat reserves at the rump and hips. Fecal pellets and hair samples were collected from 80% of individuals for future genetic and hormonal analyses.

Transport and acclimatization

All 15 deer were safely transported approximately 130 km from the Khan-Undur donor sites to the Bukhun Shar Mountains within the same day of capture (travel time 2–3 hours). No transport-related mortality, injury, or agitation was recorded. Continuous observation confirmed normal posture and calm breathing throughout transit.

Upon arrival, deer were placed in acclimatization pens for recovery and adaptation. The holding period lasted about five months (December–May) in 2020 and 2022, and approximately three months (December–February) in 2024–2025. Daily checks confirmed stable health and feeding responses in all individuals. No mortality or major illness occurred during this stage.

Behavioral adaptation in acclimatization pens

During the acclimatization phase, the SMD adjusted well to the enclosure environment. Average daily feed intake per individual was estimated at 1.2 ± 0.3 kg, consisting mainly of hay (≈ 70%) and lichens + mosses (≈ 30%). Feeding activity was recorded during 93% of observation days, and food refusal occurred in less than 5% of cases.

Animals maintained normal behavior patterns, spending much of the day resting in shaded or covered areas and becoming more active during dawn and dusk. Calm postures, slow movements, and occasional social sniffing were frequently observed, while aggressive interactions were absent.

By late winter, deer displayed increased vigilance, frequent exploration of enclosure boundaries, and responsiveness to environmental stimuli such as sound and scent, indicating readiness for soft release.

Release and post-release observations

Releases were performed during calm daylight conditions in spring. Each individual exited the pen independently and moved into nearby forest cover without signs of panic. During the first three weeks post-release, 11 of 15 individuals (73%) were repeatedly detected through direct sightings, fresh tracks, or fecal pellets within 1–2 km of the release site.

Subsequent ranger patrols documented feeding signs and tracks of at least nine individuals (60%) over the following two months, suggesting stable site fidelity during the initial adaptation phase. Occasional wolf (*Canis lupus* Linnaeus, 1758) tracks were recorded near the release area, but no direct evidence of predation was found.

Overall, survival during capture, transport, and acclimatization was 100%, and post-release observations confirmed successful adaptation and early settlement of the reintroduced SMD population in the Bukhun Shar Mountains.

Discussion and Conclusion

The successful capture and translocation of 15 SMD between 2020 and 2025 clearly demonstrate the feasibility of drive-net capture and soft-release methods for this elusive ungulate in Mongolia. The absence of capture-related mortality and the presence of only minor superficial abrasions confirm that the applied technique meets modern animal welfare standards. Drive-netting proved to be one of the safest and most practical approaches for small ungulates in rugged, forested terrain where drop-nets or net-guns are often impractical (Taylor, Reynolds & Ballard, 2005). Comparable success has been reported for other cervids, including European fallow deer (*Dama dama* Linnaeus, 1758) in Australia (Bengsen *et al.* 2021) and Mule deer (*Odocoileus hemionus* Rafinesque, 1817) in North America (Smedley *et al.*, 2023). Although labor-intensive, this coordinated capture approach minimized stress and ensured humane handling, providing a practical and replicable method for future conservation actions in similar mountainous habitats.

The slightly female-biased sex ratio (2 ♀ : 1 ♂) likely reflects demographic structure in the donor population or behavioral differences affecting detectability during winter captures. Adult females of *M. moschiferus* tend to use lower elevations and denser forest stands in winter, where drive-net operations were concentrated, increasing their likelihood of capture. Similar female-skewed results have been reported in other small-ungulate translocations (Fischer & Lindenmayer, 2000; Bubac *et al.*, 2019). Although the sample size was limited, these findings emphasize the importance of monitoring sex and age structure in founder populations to maintain demographic and genetic balance.

Chemical immobilization was deliberately avoided to reduce the risk of capture myopathy, hypothermia, and drug-related complications. The exclusive use of physical restraint and rapid handling resulted in 100% survival and minimal stress responses. This outcome supports the principle that well-coordinated manual restraint can be safer for small, stress-sensitive ungulates than chemical immobilization, especially under cold winter conditions. Similar conclusions have been drawn from live-capture programs for other temperate ungulates (Arnemo & Kreeger, 2018; Baumgardt *et al.*, 2023).

The 100% survival rate during short-distance (2–3 h) road transport further demonstrates that such transfers are safe and efficient for SMD when appropriate handling protocols are applied. The use of small ventilated crates lined with straw and constant supervision ensured stable physiological responses. Comparable results were obtained in translocations of Siberian roe deer (*Capreolus pygargus*) and goitered gazelles (*Gazella subgutturosa* Güldenstädt, 1780), where same-day transfers minimized post-transport stress (Letty, Marchandeau & Aubineau, 2007; Hayward & Somers, 2009).

Acclimatization enclosures played a crucial role in the overall success of this reintroduction. Deer housed for three to five months exhibited stable feeding activity, calm behavior, and strong site fidelity after release. As reported in other ungulate studies, pre-release holding allowed individuals to regain body condition, adapt to local environmental stimuli, and reduce post-release stress (Bubac *et al.*, 2019; Thévenin *et al.*, 2020). The observed behavioral stability and consistent feeding indicate that the enclosure design and husbandry methods were appropriate for the species' ecological needs. Nonetheless, the duration of the acclimatization period should be optimized to balance gradual adaptation with the need to avoid habituation to human presence or dependence on supplementary feeding.

Post-release field observations confirmed that the released individuals adapted rapidly to their new environment, as indicated by regular sightings, fresh tracks, and feeding signs recorded near the release sites. These findings demonstrate strong site fidelity and early settlement success.

Predation is among the primary causes of early post-release mortality in ungulate reintroductions (Hayward & Somers, 2009; Seddon *et al.*, 2012). Occasional wolf (*C. lupus*) tracks indicated potential predation risk, but no direct mortality was detected. The absence of such events in this study suggests that pre-release acclimatization pens and soft-release methods effectively reduced immediate vulnerability to predators.

From a conservation standpoint, this initiative represents the first officially documented reintroduction of *Moschus moschiferus* in Mongolia and provides a practical model for future recovery programs of small forest ungulates. The integrated protocol — encompassing capture, transport, acclimatization, and soft release — proved both humane and operationally effective under harsh winter conditions.

Compared to Russia, where conservation efforts have largely centered on *in situ* strategies such as anti-poaching enforcement and habitat protection, the Mongolian program marks a shift toward active reintroduction. Russian studies have shown that musk deer exhibit strong site fidelity and occupy small home ranges in old-growth forests with abundant lichens (Maksimova *et al.*, 2014), highlighting the importance of habitat quality over large-scale movement. While captive breeding has been considered in Russia, authors such as Prihodko (2019) argue that low reproductive success and inbreeding risks make it an impractical recovery tool. Instead, he advocates for strict hunting moratoriums and wild population support as the most viable path forward (Prihodko, 2018).

In this context, Mongolia's soft-release approach following multi-month acclimatization offers a novel addition to regional musk deer conservation techniques. This divergence reflects both ecological and political differences: in Russia, fragmented populations persist under protection, while in Mongolia, extirpated local populations require re-establishment. The shared lessons, however, are clear — any translocation program must integrate detailed ecological data, careful animal handling, and post-release monitoring, whether in Primorye or the Khangai Mountains.

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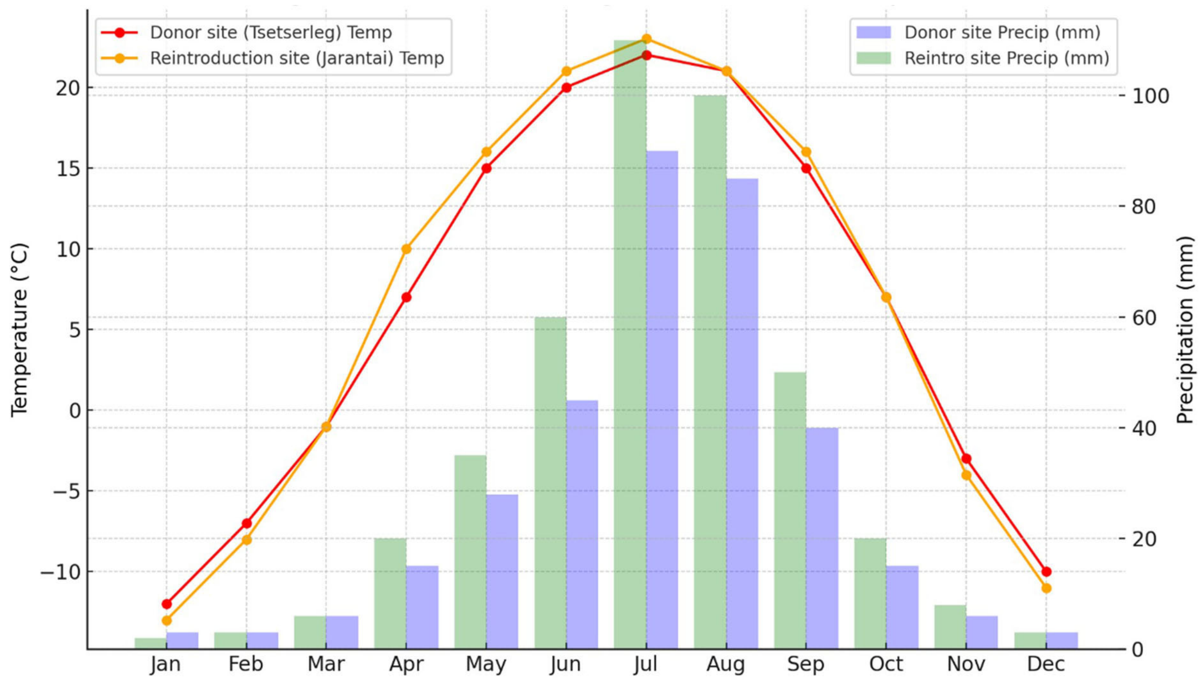

Fig. S1. Climate diagram of the donor site (Tsetserleg, Arkhangai; red line — mean monthly temperature, blue bars — precipitation) and the reintroduction site (Jarantai, Arkhangai; orange line — mean monthly temperature, green bars precipitation). Data represent 30-year climate means (1981–2010) derived from Meteoblue (ERA5T reanalysis model).

Fig. S2. (Left) Siberian musk deer resting in a transport crate; (Right) Drive-net enclosure used for capture.

Fig. S3. Field team securing a Siberian musk deer (*Moschus moschiferus*) after drive-net capture. The animal's eyes were covered to reduce stress, and handlers maintained sternal recumbency while disentangling the net prior to transport.

Fig. S5. Siberian musk deer (*Moschus moschiferus*) in an acclimatization pen, Bukhun Shar Mountains.

Fig. S4. Facilities used for translocation and acclimatization of Siberian musk deer (*Moschus moschiferus*). (Left) Temporary acclimatization pen (100 m × 100 m) constructed with mesh fencing in the Bukhun Shar Mountains. (Right) Wooden ventilated transport crate used to safely transfer individuals from capture site to release area.