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RESEARCH ARTICLE

Rehabilitation of Bukharan markhor *Capra falconeri heptneri* Zalkin, 1945 numbers in Uzbekistan

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Abstract

During the first half of the twentieth century, Bukharan markhor (*Capra falconeri heptneri* Zalkin, 1945) experienced a pronounced population decline in Uzbekistan, creating an urgent need for the establishment of specially protected areas to conserve and restore the species. Currently, the Surkhan State Nature Reserve (Uzbekistan) and the Koytendag (Kugitang) State Nature Reserve (Turkmenistan) protect the main habitats on the Kugitang Ridge, while the 'Surkhan' hunting farm was established in the degraded parts of the ridge, where markhor was historically rare due to the continuous presence of livestock, human disturbance, and a depleted forage base. The objective of this study was to assess the role of the newly created hunting farm in the recovery of markhor numbers and habitat and to determine the current population status through systematic counts within the farm and adjacent territories. Seasonal monitoring conducted between 2019 and 2024 revealed a substantial and sustained increase in population. In the first year after the establishment (2019), approximately 30 individuals were recorded on the farm and 60 in the adjoining Tangiduval Gorge; these levels were maintained in 2020. At the beginning of 2021, the numbers within the hunting farm increased markedly to 52 markhors, with more than 100 individuals recorded in the Tangiduval sector. By 2022, the population continued to grow, reaching 82 individuals on the farm and 137 outside it. In early 2023, numbers had largely stabilized, with 146 markhors counted (50.0% on the farm, 50.0% in Tangiduval). By late 2023, the population reached 121 individuals on the farm and 140 in the adjacent area, yielding a total of 261 markhor for the study zone; this level was maintained until early 2024. During the study period, the markhor population within the hunting farm increased 4.5 times and that in the Tangiduval Gorge

2.7 times. Integrating these results with reserve data, the current markhor population on the Uzbek portion of the Kugitang Ridge is estimated at approximately 900 individuals, comprising more than 620 animals within the Surkhan State Nature Reserve and 260 in the hunting farm and its adjacent areas. The rapid recovery observed demonstrates that the implementation of targeted biotechnical and habitat management measures, combined with the restoration of the forage supply and the regulation of human disturbance, can stimulate significant population growth over a short period. These findings underscore the conservation value of well-managed hunting concessions as a complementary tool to strict protected areas for the recovery of threatened mountain ungulates.

Keywords
Abundance, conservation, markhor *Capra falconeri heptneri*, markhor numbers, restoration

Introduction

The Bukharan markhor, *Capra falconeri heptneri* Zalkin, 1945 (Bovidae), is a straight-horned subspecies of the markhor wild goat, listed in the Red Data Book of the Republic of Uzbekistan as Critically Endangered and considered a locally distributed subspecies (Sultanov 1983; Abdunazarov 2003, 2006, 2009; Abdunazarov & Bykova 2019). Its threatened status is recognized regionally, with the subspecies also included in the national Red Data Books of Tajikistan (Amirov 2017) and Turkmenistan (Marochkina & Menliev 2011), on the IUCN Red List as Near Threatened (Michel & Rosen Michel 2015), and in Appendix I of CITES.

Over the past several decades, throughout the species' distribution range, despite the conservation measures implemented, the challenges of species conservation, population management, and protection of natural habitats have remained highly relevant (Ashraf et al. 2014; Bhatnagar et al. 2009; Haider et al. 2021; Michel et al. 2014; Weinberg et al. 1997).

The only known population of Heptner's markhor in Uzbekistan occurs on the Kugitang Range (Köýtendag), which straddles the border between southeastern Turkmenistan and southern Uzbekistan (Weinberg et al. 1997; Michel et al. 2014). Data specific to the Uzbekistan side are historically sparse. Weinberg et al. (1997) reported that the Kugitang Nature Reserve in Turkmenistan harbored at least 227 individuals during a 1995 survey covering roughly 35% of available habitat, and noted that a portion of that population also used the Uzbekistan slope. At that time, the transboundary population appeared to be increasing, a trend attributed to the removal of livestock, improvement in range conditions, and enhanced antipoaching enforcement (Weinberg et al. 1997). Michel et al. (2014) later characterized the Uzbekistan portion of this transboundary population as relatively small and, given its national status in the Red Data Book, precarious. Globally, the total number of mature Heptner's markhor across all range states was then estimated at fewer than 2,500 individuals (Michel et al. 2014).

Tajikistan supports the largest extant population of Heptner's markhor. A comprehensive survey in 2012 counted 1,018 individuals across approximately 36,000 ha of habitat in the Darvaz and Hazratishoh ranges of southern Tajikistan (Michel et al. 2014). The population exhibited a well-balanced sex and age structure, with a young-to-female ratio of 0.97, indicating high reproductive success. The highest densities were recorded in community managed conservancies, M-Sayod (8.56 animals/km²) and Morkhur (13 animals/km²), where local protection had been in place since the early 2000s, allowing an increase from as few as 23 animals in 2003 to 236 by 2012 (Michel et al. 2014). In Turkmenistan, the 1995 survey of the Kugitang Reserve recorded 227 markhors, and the population has remained relatively stable, forming a transboundary stock with the animals on the Uzbekistan side (Weinberg et al. 1997).

Historically, markhor in Uzbekistan were documented on both the Kugitang and Babatag ridges (Sultanov 1953, 1983; Volozheninov et al. 1985). However, by 1981 the species had been extirpated from the Babatag ridge (Shernazarov et al. 2020). Ongoing habitat degradation and population fluctuations in the remaining range are driven primarily by anthropogenic pressures, among which competition with livestock for pastures and illegal hunting are the main negative factors (Shernazarov et al. 2020).

Early ecological investigations by Sultanov (1953), carried out between 1935 and 1940, provided a detailed account of markhor biology and ecology in southern Uzbekistan and raised the necessity of protecting the species through the creation of specially protected areas. In 1947, Zheleznyakov (1952) surveyed the eastern slopes of the Kugitang ridge to identify the main concentrations of markhor and delineate the boundaries of a proposed reserve. These efforts eventually led, in 1970, to the establishment of a mountain forest reserve on the eastern slopes, which was subsequently transformed into the Surkhan State Nature Reserve in 1986. In the same year, the Kugitang (Koitendag) State Nature Reserve was established on the western slope of the ridge in Turkmenistan, formalizing a transboundary protected area network for the subspecies.

To further promote the sustainable use of biological resources, a hunting farm was established on the Kugitang ridge in the southern part of Uzbekistan. The surveyed areas support a community of game mammals, such as Indian porcupine (*Hystrix indica*), badger (*Meles meles*), wolf (*Canis lupus*), fox (*Vulpes vulpes*), steppe cat (*Felis lybica*), stone marten (*Martes foina*) and the chukar partridge (*Alectoris chukar*), and historically the markhor was also considered a game species.

For several decades, the published literature has repeatedly cited a markhor population of approximately 400 individuals in Uzbekistan (Sultanov 1983; Abdunazarov 2003, 2006, 2009; Abdunazarov & Bykova 2019). The most detailed census data, however, pertain exclusively to the core habitat on the Kugitang ridge, the territories of the Surkhan State Nature Reserve, and the hunting farm (Zheleznyakov 1952; Sultanov 1953; Khalikov 2002, 2004; Shernazarov et al. 2020, 2021). At the beginning of the present century, the markhor population within this area was

estimated at only 200 individuals (Abdunazarov, 2003), of which 140–150 (75%) were located within the Surkhan State Nature Reserve (Khalikov, 2002). A spring census in 2003 suggested an increase of 160–180 individuals in the reserve (Khalikov 2004). Autumn counts in 2010 and 2015 further documented growth, yielding 250–255 and 380–385 animals, respectively (Khalikov & Mamarajabov 2016). According to unpublished records, this upward trend has continued: 607 markhors were recorded in 2021, and 621 at the end of May 2022 (Khalikov, Tashkent, personal communication, 2022).

Thus, existing published data do not adequately capture the contemporary situation of the markhor in Uzbekistan, nor do they provide a systematic analysis of negative changes in range and population size or the effectiveness of the conservation measures implemented. No recent systematic field surveys focusing on the Uzbekistan side of the Kugitang Range have been published in the international peer-reviewed literature. To address this gap, the present study integrates historical published records with systematically collected field monitoring data on markhor numbers at the principal aggregation sites. The objective is to provide an impartial, data-driven assessment of the current population status and to evaluate the role of the newly established hunting farm in the recovery of the subspecies on the Uzbek portion of the Kugitang Ridge.

Materials and methods

Field monitoring data on the current status of the markhor *Capra falconeri heptneri* (Zalkin, 1945) population were collected within the "Surkhan" hunting farm (1,300 ha) and in adjacent areas on the left slope of the Tangiduval Gorge (1,800 ha) on the Kugitang Ridge in southern Uzbekistan (Fig. 1). Surveys were carried out in September to October 2019, November 2020, February 2021, March and November 2022, February and December 2023, and February 2024. Animal counts were carried out using vehicle and foot transects, together with point count methods, at 10 fixed observation points (Temirkok: N 38.000068°, E 66.818646°, 2,044 m a.s.l.; Kulbat: N 37.989987°, E 66.828366°, 1,984 m a.s.l.; Zarvus: N 37.985578°, E 66.806340°, 1,556 m a.s.l.; Chambar: N 37.993338°, E 66.799988°, 2,003 m a.s.l.; Bodomzor: N 37.970805°, E 66.790835°, 1,313 m a.s.l.; Tuyabuyin: N 37.985342°, E 66.793065°, 1,477 m a.s.l.; Ziralikiya: N 37.986501°, E 66.775854°, 1,425 m a.s.l.; Archabesh: N 37.979521°, E 66.747054°, 1,489 m a.s.l.; Tillabulok: N 37.976837°, E 66.721400°, 1,505 m a.s.l.; Kuyukdara: N 37.984045°, E 66.716168°, 1,549 m above sea level), following established methods for mountain terrain (Baidavletov 2003; Plakhov and Bekenov 2003). Throughout the study area, the markhors were recorded at elevations ranging from 1,212 to 2,014 m above sea level.

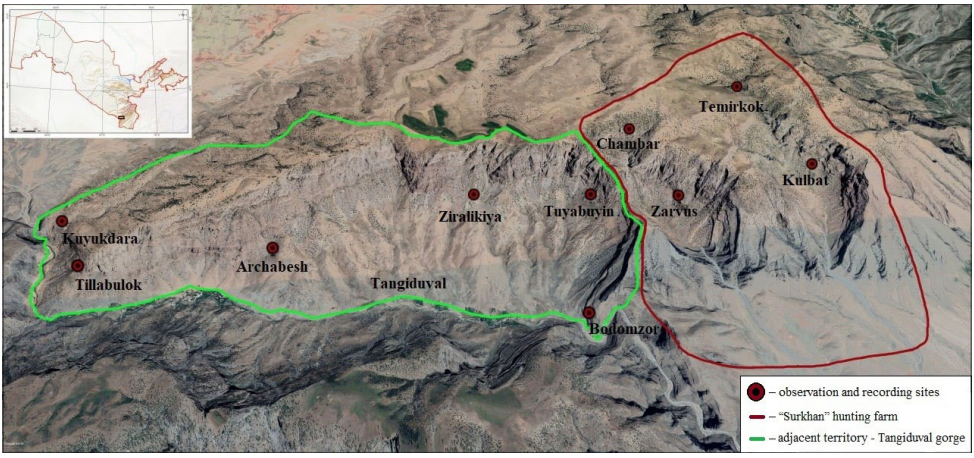

Figure 1. Markhor *Capra falconeri census* areas on the Kugitang Ridge.

Results

Before the establishment of the 'Surkhan' hunting farm, local residents reported that markhor occurred in the Zarvus and Kulbat gorges in groups of 10–15 individuals. Khalikov (2014) corroborates these observations, noting that two groups (of two and five individuals) were recorded in Kulbat in spring 2003, although none were detected there in summer that year. It is likely that the species was also present in small numbers in the adjacent Tangiduval Gorge.

During the first two years after the farm's establishment (2019–2020), approximately 90 markhors were counted across the 'Surkhan' hunting farm and adjacent areas in the Tangiduval Gorge, with 30.0% of the animals located on the farm and 70.0% in Tangiduval (Shernazarov et al. 2020, 2021). At that time, the markhor density was estimated at 2–3 individuals/km^2.

At the beginning of 2021, the number of animals within the hunting farm increased markedly during the winter season. At the end of February, 52 markhors were present, of which 36 (69.2%) were recorded in the Zarvus Gorge and 16 (30.8%) in Kulbat. In the Tangiduval section, more than 100 individuals were counted at the intersection points of Bandak and Tillabulak. These survey results indicate that the population adapted to the newly favorable conditions and, correspondingly, that the number of animals on the hunting farm approximately doubled during the first years after its establishment. Furthermore, a substantial increase in numbers persisted in subsequent years (Fig. 2). Thus, in mid-March 2022, 41 markhors were recorded in each of the two gorges of the hunting farm, Zarvus and Kulbat (82 in total), while 137 individuals were counted outside the farm, exceeding the number recorded in the winter of the previous year. In 2021, the markhor

density increased to 4 individuals / km² and the growth continued; by March 2022, the density reached 6 individuals/km².

In the autumn, at the end of November 2022, the number of markhors in the hunting area remained relatively stable, with 71 individuals counted, while in the Tangiduval Gorge the count (76 individuals) was almost half that recorded in March. This decline probably reflects dispersal in search of food and the onset of the rutting period.

A comparison of counts from the third decade of November 2022 and the second decade of February 2023 suggests that the total number of study species had largely stabilized within the study area. Specifically, on February 20, 2023, we recorded 146 markhors, of which 73 (50.0%) were located within the hunting farm and an equal number in the Tangiduval Gorge. The spatial distribution among the hunting farm remained, as is typical: 52 markhor (71.2%) were recorded in the Zarvus Gorge and 21 (28.8%) in the Kulbat Gorge in February. In contrast, in December 2023 the number of markhors was higher in the Kulbat Gorge (67 individuals, 55.4%) than in the Zarvus Gorge (54 individuals, 44.6%). During this month, the numbers outside the farm were also high (140 individuals), yielding a total of 261 markhor recorded in the studied section of the Kugitang Ridge that winter. In February 2024, the markhor numbers remained virtually unchanged. During the winter period of 2023-2024, an increase in density was observed in the surveyed areas. From 2019 to 2024, the relative annual increase in the number of hunters within the hunting farm ranged from 6.6% to 42.3%, averaging 21.8%.

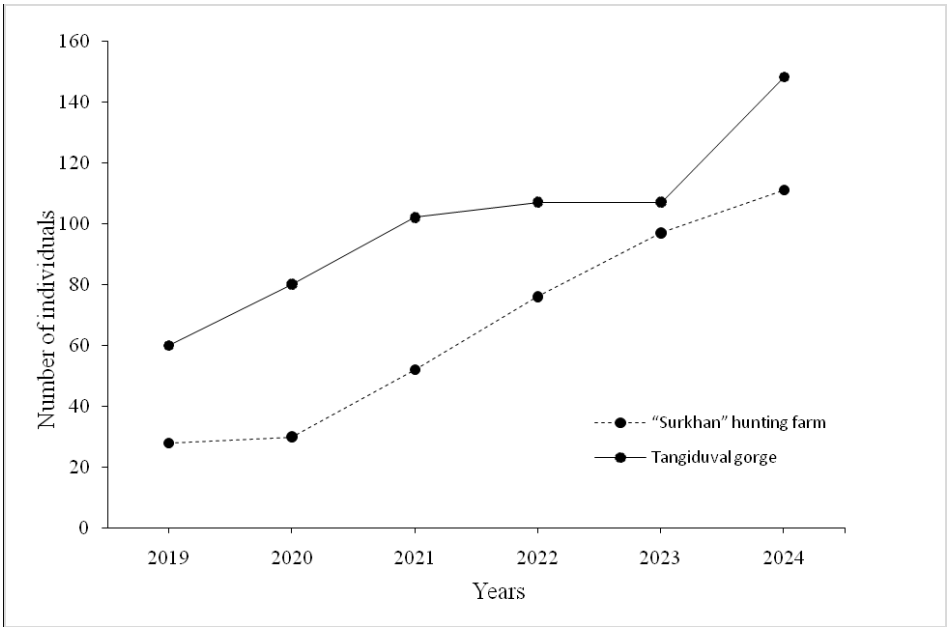

Figure 2. Dynamics of markhor numbers in the 'Surkhan' hunting farm and adjacent territories of the Kugitang Ridge, based on censuses conducted from 2019 to 2024.

Discussion

Analysis of published historical records (Sultanov 1983; Abdunazarov 2003, 2006, 2009; Khalikov 2002, 2004), unpublished census data from Surkhan State Nature Reserve (Khalikov & Mamarajabov 2016; Khalikov, personal communication 2022), and the present field surveys reveal a twofold increase in the markhor population within the study area of the Kugitang Ridge over the past two decades. Surkhan State Nature Reserve remains the main stronghold, supporting more than 70% of all animals recorded on the Uzbek side of the range. The present study also shows that, over the five-year period 2019–2024, the establishment of the 'Surkhan' hunting farm and the adjacent Tangiduval Gorge has been accompanied by an approximate threefold increase in the local population, increasing from ~90 individuals (Shernazarov et al. 2020, 2021) to 261 by winter 2023–2024. Within the hunting farm itself, the numbers increased approximately fourfold, from 30 to 121, while the density of animals throughout the managed zone increased from 2 to 9 markhor/km^2. These data constitute the first systematic, multiyear evidence of a sustained positive population trajectory for Heptner's markhor on the Uzbek portion of the Kugitang Range.

The proximate drivers of this local recovery are evident. With the creation of the hunting farm, grazing of livestock was eliminated from the outset, initiating rapid restoration of vegetation communities that had been heavily degraded by domestic small ruminants. The resultant improvement in forage availability, coupled with a strictly maintained calm environment, the complete exclusion of domestic dogs, and continuous antipoaching patrols, generated conditions to which markhor responded swiftly. Supplementary biotechnical measures, winter feeding and the provision of salt licks, further enhanced habitat quality and probably contributed to improved overwinter survival and reproductive output. The observed stabilization of numbers by early 2023, with only minor cyclical fluctuations thereafter, suggests that the local subpopulation may be approaching the carrying capacity of the restored habitat under current management, although longer-term data will be required to distinguish density-dependent regulation from stochastic environmental variation. Crucially, no evidence of infectious disease was detected during the study period, indicating that the biosecurity afforded by the exclusion of domestic livestock has been effective.

The recovery documented here mirrors, on a smaller scale, the well-known success stories of community-based trophy hunting programs (CTHP) in Pakistan and Tajikistan. In these countries, the channelling of 80% of substantial trophy fees to local communities transformed poachers into guardians and funded both conservation and social development, catalyzing dramatic population increases: the Astor markhor in Gilgit-Baltistan rose from ~1,900 to ~2,800 between 2012 and 2016, the Kashmir markhor in Khyber Pakhtunkhwa from 2,493 to 4,878 during a similar period, and the Sulaiman markhor in Balochistan from 1,742 to 3,518 within a decade (Adhikari et al. 2021). In Tajikistan, community conservationists such as

M-Sayod and Morkhur enabled local Heptner markhor populations to grow from as few as 23 animals in 2003 to more than 200 by 2012 (Michel et al. 2014). The "Surkhan" hunting farm represents a distinct but conceptually related model: a strictly protected area, operated as a hunting concession, where the removal of anthropogenic pressures has yielded similar rapid demographic gains even in the absence of the direct community revenue-sharing mechanisms that underpinned recovery elsewhere. This outcome aligns with evidence from Tajikistan that protected areas where livestock grazing and poaching are effectively controlled, characteristics of the community conservancies but not of the weakly enforced Dashtijum Strict Reserve, can support robust markhor populations (Michel et al. 2014). The Uzbek experience thus reinforces the principle that the elimination or substantial reduction of competition with livestock and human disturbance is a prerequisite for population recovery, irrespective of the specific governance model.

However, the present success must be interpreted in the context of persistent, range-wide threats that continue to challenge markhor conservation globally. The near-total dietary overlap between markhor and domestic goats in summer and the documented catastrophic outbreak of *Mycoplasma capricolum* pneumonia that killed approximately 20% of a Tajikistan population in 2010 (Ostrowski et al. 2011; Ashraf et al. 2014) serve as stark warnings that any relaxation of livestock exclusion or biosecurity could rapidly reverse local gains. The fragmentation of populations, particularly acute among the straight-horned forms in Pakistan (Schaller & Khan 1975) and the Kashmir markhor in India, where subpopulations typically number fewer than 50 individuals (Bhatnagar et al. 2009) raises concerns about genetic viability and demographic stochasticity that will require metapopulation management strategies. The current study directly addresses a conspicuous knowledge gap highlighted in previous reviews: the status of Heptner's markhor on the Uzbekistan side of the Kugitang Range, for which only two-decade-old estimates were available (Weinberg et al. 1997; Michel et al. 2014). Our integrated census data now allow for a robust contemporary estimate of ~900 individuals in the Uzbek portion of the range, comprising over 620 in the Surkhan State Nature Reserve and 260 in the hunting farm and adjacent Tangiduval Gorge. This revised figure substantially increases the known global population of the subspecies and underscores the critical importance of this transboundary system for the long-term survival.

The findings have direct implications for conservation policy. First, they demonstrate that well-managed hunting concessions, when combined with rigorous habitat protection and biotechnical interventions, can serve as highly effective complementary tools to strict nature reserves for the rehabilitation of threatened mountain ungulates. Second, rapid recovery on formerly degraded lands indicates that habitat restoration is achievable within management-relevant timescales if key stressors, particularly livestock grazing and the presence of dogs, are removed. Third, the success of community-based models elsewhere strongly suggests that the integration of local communities into benefit-sharing mechanisms would enhance the long-term sociopolitical sustainability of the "Surkhan" initiative; such an approach would

align with the global paradigm shift toward community-led conservation and could be facilitated by the transboundary cooperation frameworks already advocated for the Kugitang Range (Michel et al. 2014). Finally, the downlisting of the markhor on the IUCN Red List (Adhikari et al. 2021) should not engender complacency. Rather, it must serve as an impetus to consolidate and expand monitoring programs, to maintain and strengthen biotechnical and protection measures, and to institutionalize disease surveillance and livestock management across the entire transboundary population, including close collaboration with the Koytendag Reserve in Turkmenistan.

Conclusion

Annual monitoring of the markhor population in the Surkhan State Nature Reserve, the "Surkhan" hunting farm and adjacent territories reveals minor cyclical fluctuations in numbers, attributable to natural environmental variation, and confirms the continued absence of infectious diseases and the high effectiveness of the current protection regime. The markhor population on the Uzbek part of the Kugitang Ridge is now estimated at more than 900 individuals, a figure that represents a conservation achievement of considerable significance and demonstrates that science-based, protection-focused management can reverse the decline of a threatened mountain ungulate, even in formerly degraded habitats.

Collective evidence from Uzbekistan and the wider global context yield several key lessons. (1) Community-based conservation with tangible economic incentives remains the single most effective tool for population recovery at the landscape scales. (2) Transparent benefit-sharing mechanisms foster local stewardship and transform social attitudes toward wildlife. (3) Regular and standardized population monitoring is essential to detect trends, setting sustainable harvest quotas and providing early warning of declines. (4) Robust disease surveillance at the livestock–wildlife interface is critical to prevent catastrophic outbreaks. (5) Active management of livestock grazing in core habitats is necessary to mitigate forage competition and habitat degradation. (6) Transboundary cooperation between Uzbekistan, Turkmenistan and Tajikistan constitutes a fundamental prerequisite for the long-term viability of Heptner's markhor throughout its entire range.

For Uzbekistan specifically, there is an urgent need to sustain the systematic survey effort in the Kugitang Range to track population dynamics, strengthen cooperative management of the transboundary population with Turkmenistan, and to explore the extension of community-based benefit sharing models to the Uzbek side. Such steps would help secure the gains already made and unlock the same positive incentives that have been proven transformative elsewhere in the species range.

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