



NATIONAL UNIVERSITY OF MONGOLIA
SCHOOL OF SCIENCE

Ankhzayaa Nasantogtokh

**Methodological Shifts in Monitoring Przewalski's Horse (*Equus ferus przewalskii*
Poljakov, 1881) : Transitioning from Individual-Based to Population-Level Approaches in
the Dzungarian Gobi**

*A thesis submitted in partial fulfillment of the requirements for the degree of
Master of Science in Biology*

Ulaanbaatar
2025

NATIONAL UNIVERSITY OF MONGOLIA
SCHOOL OF SCIENCE
DIVISION OF NATURAL SCIENCES
DEPARTMENT OF BIOLOGY

Ankhzayaa Nasantogtokh

**Methodological Shifts in Monitoring Przewalski's Horse (*Equus ferus przewalskii*
Poljakov, 1881) : Transitioning from Individual-Based to Population-Level Approaches in
the Dzungarian Gobi**

Field of Study Index: **E 05110101 (Biology)**

A thesis submitted in partial fulfillment of the requirements for the degree of
Master of Science in Biology

Supervisor: / Dr., Prof. D. Lkhagvasuren /

Reviewer: / Dr. D. Usukhjargal /

**ULAANBAATAR CITY
2025**

COPYRIGHT PAGE

© 2025 Ankhzayaa Nasantogtokh

All rights reserved.

No part of this thesis may be reproduced, stored in a retrieval system, or transmitted in any form or by any means — electronic, mechanical, photocopying, recording, or otherwise — without prior written permission of the author or the National University of Mongolia.

©2025

ANKHZAYAA NASANTOGTOKH

ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to my supervisor, Dr. Prof. D. Lkhagvasuren of the Department of Biology, School of Science, National University of Mongolia, and to Dr. Prof. Petra Kaczensky of Inland Norway University of Applied Sciences for their valuable guidance and advice. My sincere thanks also go to O. Ganbaatar for directing the field research, and to the dedicated staff of the Administration of the Great Gobi "B" Strictly Protected Area for their continuous support and collaboration. Finally, I am truly grateful to the International Takhi Group for providing the scholarship that covered my tuition fees.

LIST OF ABBREVIATIONS

USA – United States of America

MPR – Mongolian People’s Republic

NP – National park

GGSPA – Great Gobi Strictly Protected Area

WWF – World Wide Fund for Nature

SPA – Strictly Protected Area

PA – Protected Area

NGO – Non-Governmental Organization

State PA – State Protected Area

SPC – State Great Khural (Parliament of Mongolia)

NAMEM – National Agency for Meteorology and Environmental Monitoring

FRG – Federal Republic of Germany

PA Admin – Protected Area Administration

ITG – International Takhi Group Association

IUCN – International Union for Conservation of Nature

SDC – Swiss Agency for Development and Cooperation

LIST OF FIGURES

Figure 1. Boundary of the Strictly Protected Area	20
Figure 2. Boundary of the Great Gobi “B” Strictly Protected Area	21
Figure 3. Grid map	22
Figure 4. Table and map of Przewalski’s horse observation data	23
Figure 5. Starting and finishing monitoring in the SMART program	24
Figure 7. Distribution range of Przewalski’s horse in SMART program	25
Figure 8. Przewalski’s horse observation routes	28
Figure 9. Total observed location of Przewalski’s horse, 2022–2025	35
Figure 10. Observed locations of Przewalski’s horse, 2022–2023	36
Figure 11. Observed locations of Przewalski’s horse, 2023–2024	36
Figure 12. Observed locations of Przewalski’s horse, 2024–2025	37
Figure 13. Comparison of the distribution range of Przewalski’s horse (2023–2025)	37

LIST OF GRAPHS

Graph 1. Population and movement dynamics of Przewalski’s horse	30
Graph 2. Population increase and decrease of Przewalski’s horse (savethewildhorse.org)	30
Graph 3. Growth rate of Przewalski’s horse population, 2022–2025	31
Graph 4. Population size and mortality of Przewalski’s horse	31
Graph 5. Birth and mortality data of foals, 1993–2025	32
Graph 6. Comparison of Przewalski’s horse population and dzud index, 2022–2024	32
Graph 7. Livestock numbers in selected baghs, 2022–2024 (www.1212.mn)	33
Graph 8. Livestock numbers in selected baghs, 2022–2024 (www.1212.mn)	34

LIST OF TABLES

Table 1. Dzud index, 2022–2024	33
Table 2. Mortality of Przewalski’s horse, 2022–2025	34
Table 3. Comparison of distribution range of Przewalski’s horse	35

TABLE OF CONTENTS

Acknowledgements III

Abstract 1

Chapter 1: Introduction 2

1.1 Background of the Study 2

1.2 Research Objectives and Goals 4

1.3 Novelty and Significance 4

1.4 Literature Review 5

Chapter 2: Physical-Geographical Characteristics of the Study Area, Research Materials, and Methods 11

2.1 Physical Geography of the Study Area 11

2.1.1 Geographic Location and Terrain 11

2.1.2 Climate 13

2.1.3 Hydrology 14

2.1.4 Soil 15

2.1.5 Vegetation 16

2.1.6 Fauna 18

2.1.7 Landscape 19

2.1.8 Study Sites and Locations 20

2.2 Research Materials and Methods 22

2.2.1 Field Research Methods 22

2.2.2 SMART Program Methodology 23

2.2.3 Data Processing 26

Chapter 3: Results 28

3.1 Population-Based Methods for Estimating Przewalski's Horse Numbers 28

3.2 Population Size and Movement Patterns 30

3.3 Factors Affecting Population Size 32

3.4 Changes in Distribution Range and Comparative Analysis 35

Chapter 4: Discussion 38

Chapter 5: Conclusion 40

Chapter 6: Recommendations 42

References 43

Research Abstract

The reintroduction of the Przewalski's horse (*Equus ferus przewalskii* Poljakov, 1881) into its natural habitat is one of the major global objectives for biodiversity conservation. The Dzungarian Gobi in southwestern Mongolia was the species' last natural range, and a reintroduction program has been implemented there since 1992.

In recent years, the population of Przewalski's horses has grown, and the extent of their potential range has expanded. As a result, it has become increasingly difficult to identify individuals, necessitating the application of updated monitoring methods for assessing population size and dynamics.

Between 2023 and 2025, we conducted research on population status, distributional changes, harem structure, demographic dynamics, and reproduction of the Przewalski's horse, using both traditional field observations and monitoring methods based on the SMART software. A total of 8,227 data points were collected. Distribution maps were developed using ArcGIS and Excel, and relationships with dzud severity index, foal mortality, and livestock numbers were analyzed.

Findings revealed a sharp population decline in 2023 and reduced foal survival, attributable to several factors, including a severe winter (dzud), mortality of dominant stallions, and *infanticide* (killing of non-offspring foals) in newly formed harems. While the SMART software proved effective in rapid data processing and distribution assessment, additional validation was required to ensure the accuracy of certain datasets.

Based on the results, we developed a methodology for population-level monitoring of Przewalski's horses and synthesized potential outcomes and risks to support long-term ecosystem monitoring and conservation management. Further recommendations include transitioning toward an integrated monitoring system combining camera traps, drones, and genetic research, as well as advancing studies on pasture vegetation and water resource availability.

CHAPTER I. INTRODUCTION

RESEARCH BACKGROUND

The Great Gobi Strictly “B” Protected Area (GGBSPA) was the last habitat of the Przewalski’s horse (*Equus ferus przewalskii*) until the 1970s, and the reintroduction of the species into this region began in 1992.

Between 1992 and 2019, a total of 131 individuals (36 stallions and 95 mares) of Przewalski’s horse were transported and reintroduced into the Dzungarian Gobi. It is therefore necessary to study the social grouping, population dynamics, distribution and habitat use of these wild horses, as well as to identify the changes taking place within them. The reintroduction of a species that has once gone extinct in the wild is of great scientific interest, as it provides the opportunity to observe how the species reestablishes its ecological niche. However, the establishment of a free-ranging population capable of surviving and reproducing independently requires many years of continuous effort.

At the Bij River Przewalski’s Horse Research and Reintroduction Center (formerly), harems of Przewalski’s horses were kept in semi-captive conditions under constant human supervision within enclosures between 1992 and 1997. During this period, the main focus was on acclimatizing freshly transported zoo animals to the harsh and arid Gobi climate, providing supplementary feeding, and preventing mortality through veterinary and husbandry measures. The first group of Przewalski’s horses was released from the enclosure in 1997 (Stauffer, 1998). From this time onwards, studies on the biology and ecology of the species were initiated. Until 1999, however, only a small number of harems inhabited the Bij River area, and thus issues of water and pasture resources were not yet a major concern.

As the wild horse population increased, and as spatial distribution and movements of individuals among harems expanded, it became difficult to identify each horse individually after 2019. In addition, changes in human resources and workforce capacity made it impossible to carry out continuous monitoring and record-keeping on a regular basis. Previously, population size and distribution in the GGBSPA had been determined by field observations, recording, and transect counts. Since June 2023, however, the introduction of the SMART program has enabled the monitoring of Przewalski’s horses through a new data collection approach.

In this study, particular attention was paid to population size, distribution range, and herd structure. Field observation data were processed using the SMART program to assess abundance and distribution.

RESEARCH AIM AND OBJECTIVES

The Dzungarian Gobi was the region where the world's last population of the Przewalski's horse (*Equus ferus przewalskii* Poljakov, 1881) once lived. Studies suggest that by the early 1970s, the species had completely disappeared from the wild. Therefore, a reintroduction program was launched in the Dzungarian Gobi in 1992.

Within the framework of this long-term program, monitoring of Przewalski's horses has been carried out at regular intervals (at least once a week). However, as the potential range of the P-horses expanded (2019) and due to the severe dzud in 2022–2023, which caused significant mortality among dominant stallions and individual P-horses, numerous new harems were formed, making it nearly impossible to identify and recognize each individual. Consequently, there arose a need to revise the methodology for estimating population size. Since 2023, the SMART program, already used in other protected areas of Mongolia, has been applied to study population size and distribution of the Przewalski's horse, and it became necessary to compare the results with those of previous methodologies.

In order to study the population size, influencing factors, and distribution of the reintroduced Przewalski's horses in the Dzungarian Gobi, as well as to assess the use of the newly introduced SMART program, the following objectives were set:

1. To implement and test monitoring methodology at the population level.
2. To determine population dynamics (2022–2025) and the influencing factors.
3. To determine the distribution and habitat use of Przewalski's horses:
 - 3.1. To evaluate and map distribution and habitat use based on field observation records.
 - 3.2. To compare data collected through the SMART program with field observation information.

INNOVATION AND SIGNIFICANCE

This study is innovative in that it evaluates a newly introduced methodology for accurately estimating population size and determining distribution at the population level.

LITERATURE REVIEW

The earliest records of the Przewalski's horse date back approximately 20,000 years. From the Gravettian to the late Magdalenian periods (20,000–9,000 BP), 2,118 engravings and paintings, along with 610 artifacts depicting horses, have been discovered in caves across western France, northern Spain, and Italy. These findings serve as evidence that wild horses once roamed as far as Europe (Boyd, 1994).

In Mongolia, the first written record appears in 1635, when Erivger Tsetsen Khan Sholoi of Khalkha reportedly captured wild horses in his territory and presented them as tribute to the Manchu Emperor. The "Report of the Princes and Dukes of Khalkha's Khotoi Banner to the Emperor," on pages 53–54, further notes that in 1637 the Manchu Emperor sent emissaries to capture wild horses. Additionally, a dictionary compiled in 1771 (the 36th year of the Qianlong Emperor of the Qing Dynasty) described the takhi as "a wild horse belonging to the family of deer" (Enkhtur, 2004).

Among the seven extant species of the horse family (Equidae), the Przewalski's horse is the only surviving true wild horse (Ösökhjargal, 2021). Folk accounts from local herders and the notes of Central Asian explorers suggest that Przewalski's horse historically ranged across the foothills of the Mongolian Altai and that, in the early 20th century, it was relatively common in the Gobi.

N.M. Przewalski undertook three expeditions to Central Asia. During his 1879–1880 journey in the eastern Dzungarian Gobi, near the foothills of the Takhin Shar Nuruu, he received the skin and remains of an unknown horse from A.K. Tikhonov. This scientifically valuable collection led I.S. Polyakov to formally describe and confirm, in 1881, the existence of a new species of wild horse.

Several other researchers have observed, documented, and even hunted Przewalski's horses in Mongolia. In 1882, brothers Grigory and Mikhail Grum-Grzhimailo collected four specimens (a stallion, a mare, and two young horses) near Gashuun Nuur, sending skins, skulls, and skeletal material to the Zoological Museum in St. Petersburg (Grum-Grzhimailo, 1892). Later, D.A. Clemens (1893–1895) collected one mare from Baitag Bogd, several foals from the Nuurst and Semigeiz rivers in the Dzungarian Gobi, and additional specimens from the Eviin Gobi and Bulgan River area. P.K. Kozlov and V.I. Rorobovsky hunted a stallion near Guchen Lake (likely "Guchin" in Mongolian) in 1895. On January 3, 1902, I.A. Konev killed a stallion and a mare near Uvur Khonin Us, transferring the skins and skulls to V.V. Zalensky of Tomsk University's Zoological Museum (Dovchin, 1969).

The tarpan, another subspecies of wild horse, went extinct by 1897 without attracting significant attention, marking the tragic loss of the last wild horse in Europe. At that time, few could have imagined that another species of wild horse—the Przewalski's horse—still survived in Asia (Boyd, 1994).

As scientific reports on the Przewalski's horse in the Dzungarian Gobi began to circulate, not only did researchers take interest, but enthusiasts in Europe also sought to capture and breed the species in captivity. Among those who played pivotal roles were the Russian noble F.E. Falz-Fein and the German animal dealer C. Hagenbeck. With the assistance of local Mongols and Russian traders in Torguud province/aimag (old) (Bulgan River area), they facilitated the capture and export of wild foals, which marked the beginning of the Przewalski's horse's spread beyond Mongolia.

A new phase in human interaction with the Przewalski's horse began in the mid-1890s, when European animal breeders and traders developed a strong fascination with the recently described species. With the initiative, financial support, and advice of Russian scientist E.A. Bichner, Central Asian explorer D.A. Clemens, and Falz-Fein, Russian trader N.I. Assanov, based in Khovd, together with his associates Vlasov and Sakharov, organized expeditions to capture foals in the Dzungarian Gobi. Clemens himself supervised one such operation in 1897. Although they managed to capture several foals, most died shortly afterward, and the exact number of foals lost remains unknown.

Number of Captured Foals and Their Consequences

Scholars record slightly differing figures regarding the number and timing of captured foals. The group led by Falz-Fein captured 6 foals in 1898, 7 in 1899, 2 in 1900, 2 in 1901, 2 in 1902, and 6 in 1903. Most of these were sent to Askania-Nova, Saint Petersburg, and Moscow. Meanwhile, German wild animal trader C. Hagenbeck's agents, W. Grieger and K. Wach, arrived in Khovd, where they also hired Assanov and local people. In 1901 they captured 52 foals, and in 1902 another 11. Of the first 52 foals, 28 survived and were transported safely to Hamburg. In total, over the course of six years (1898–1903), 88 foals were captured (Dulamtsere, 1991; Boyd, 1994; Enkhtur, 2004, 2009).

The capture method was as follows: in spring, during foaling season, harems with newborn foals were chased on horseback until the foals were exhausted and caught. Due to a lack of experience in feeding and caring for wild horse foals, many died soon after capture. During these chases, the stallion played a critical role—when foals or mares lagged behind, he would push them with his muzzle back into the center of the harem and then charge directly at the mounted hunters, often being the first to fall to bullets. As the disrupted harem scattered, hunters lassoed and seized foals. Capturing foals in the Dzungarian Gobi for 6–7 consecutive years, especially in key foaling grounds, drastically reduced the Takhi population. Moreover, the removal of leading stallions and mares disrupted harem structures, driving young individuals away from their groups. This inflicted undeniable and severe damage to the natural population of Przewalski's horse (Dulamtsere, 1991).

At the same time as wild Takhi were disappearing in Mongolia, conditions in zoos and reserves also deteriorated. Inbreeding increased (Bouman & Bos, 1979; Bouman-Heinsdijk, 1982), genetic diversity declined (Geyer & Thomson, 1988; Geyer et al., 1989; Ryder, 1994; Oakenfull, 2000), and although reproduction was frequent, mortality was high and lifespans shortened (Bouman & Bos, 1979; Bouman & Heinsdijk, 1982).

The main causes of the Takhi's range contraction were: the mass domestication of horses, which pushed wild horses from fertile grasslands into arid regions; the occupation of open water sources and springs in the Gobi by people and livestock; the unscientific capture of foals between 1898 and 1903; overhunting before protective laws were established; heavy poaching by Ospan's armed groups near Mongolia's border in the 1940s–1950s; and the devastating dzuds (harsh winters) of 1944–1945 (Dulamtsere, 1991).

It is assumed that historically the Takhi's range extended across the Eurasian steppe. However, based on Przewalski's 1883 report, combined with Grum-Grzhimailo's 1896, Pevtsov's 1879, Noack's 1902, and Klements' 1903 findings, Garutt and colleagues concluded that the population's range had already shrunk considerably. By 1958, A.G. Bannikov reported that the Takhi were restricted to the Dzungarian Gobi, with their northern limit along the Orong River and the Altai Mountains (the northernmost point at 46°N, 90°E), the eastern boundary at 95°E, the southern limit at the Tien Shan Mountains (44°N), and the furthest western edge at 86°E. The core distribution area lay between 89–94°E and 44°30'–45°30'N, encompassing ranges such as Baitag Bogd and the Takhin Shar Nuruu (Mohr, 1971).

In 1959, the First International Conference on the Conservation of the Takhi, held in Prague (then Czechoslovakia), made several crucial decisions relevant to our research:

- The 228 Takhi recorded between 1898 and 1959, whether captured in the Mongolian Gobi or born in zoos and reserves, were compiled and published in the work *Das Urwildpferd* (Mohr, 1959), which was to serve as the official studbook for all Takhi populations worldwide.
- The centralized studbook would henceforth be maintained at Prague Zoo.
- Research into the status of the wild Takhi population would be prioritized.

Following this decision, Dr. Prof. D. Tsevegmid, a pioneering national researcher and head of the Institute of Science and Higher Education at the time, conducted field research in 1959 and 1960 across the Altai's fore-Gobi and the Takhi's range. His results were published in *Baidaliin Ukhaan* (Bold & Tsevjejav, 1963) and in the Institute of Biology's scientific works (Dovchin, 1969) (Ösukhjargal, 2021).

Thus, reports appeared that cast doubt on the continued existence of Takhi in their native range (Bannikov, 1966; Akimushkin, 1966; Sokolov, 1967). In

response, an exploratory survey team led by N. Dovchin of the Mongolian Academy of Sciences (1967–1968) compiled oral accounts from local herders and systematically searched reported locations. On 27 May 1967, two Takhi (a mare with foal) were directly observed at the eastern end of Govi Serten Mountain, approximately 25–30 km southeast of Takhi Us. On 8 June 1968, a single Takhi (age and sex undetermined) was recorded near a small dark hill called Khorgoljiin Khar, southwest of Toodog Us (Dovchin, 1969). These observations represent the last confirmed records of Takhi in the wild in Mongolia.

At present, no local residents familiar with Khorgoljiin Khar Hill—now within the territory of Great Gobi “B” Strictly Protected Area could be found. Through field searches, the site was re-identified: 4.2 km southwest of Toodog Us, northeast of Mount Uushgi (1888.7 m), southeast of Mount Aguit (1798.1 m), and west of Bavin Tolgoi (1686.0 m), at elevation point 1763.6 (N 45.167000, E 93.456000). Oral testimony by O. Ganbaatar (2024) confirmed this location.

From one perspective, the natural population had become extinct; from another, the captive population—with its limited genetic resources—left reintroduction as one of the few viable strategies for preserving the species. This decision was formalized at the Third International Conference on the Conservation of the Takhi, held in Munich, FRG, in 1976, where preparations for reintroduction were initiated. However, since the project required vast areas of land and substantial foreign support, funding for the costly reintroduction to Mongolia was not immediately available.

The Fourth International Conference on the Takhi, convened in Winchester, UK, in 1980, invited experts in wildlife management, behavioral studies, and captive breeding. A Takhi Conservation Fund was established, and the principle was adopted that Takhi should not be released directly from zoos into the wild but should first pass through semi-wild reserves. In parallel, the Takhi Foundation was also established in the Netherlands, which, together with WWF, initiated reserve creation. With financial support from WWF Netherlands, Takhi with diverse bloodlines were transferred from the USA, Ukraine, and various European zoos.

Breeding herds with unrelated stallions and bachelor groups were settled in five semi-wild reserves in the Netherlands and Germany, ranging from 30 to 265 ha. The horses were kept without supplementary feeding and under minimal human influence, thereby encouraging the development of natural behaviors and restoring wild instincts. At least one generation was maintained under these conditions to establish healthy, non-hybridized, socially functional herds capable of survival once reintroduced.

With support from the Food and Agriculture Organization (FAO) and the United Nations Environment Programme (UNEP), a meeting held in Moscow in

May 1985 concluded that reintroduction was feasible in the species' historical range, particularly the steppe regions of East Asia and western Mongolia (Boyd, 1994).

The Hustai Nuruu site was selected for reintroduction following the proposal of the Mongolian–Russian Joint Biological Expedition. The decision was endorsed by the Mongolian Association for the Conservation of Nature and Environment, the Dutch Takhi Foundation, and researchers of the Institute of Biology at the Mongolian Academy of Sciences (Bandi, 2012). Reintroduction efforts continued with releases in 2004 at Khomiin Tal, Durvuljin soum, Zavkhan aimag, and since 2028, preparatory and baseline research has been conducted at Nomrog Strictly Protected Area, Halhbol soum, Dornod aimag.

With the support of German citizen Christian Oswald, the first five Takhi were transported on 6 June 1992 from the Askania-Nova Biosphere Reserve, Ukraine, to Takhiin Tal, Bugat soum, Govi-Altai aimag. Takhiin Tal lies on the northeastern edge of Great Gobi Strictly Protected Area, Section B, where the horses were initially released into a 160-ha enclosure (Slotta-Bachmayr, 2004). The first herd was released from the enclosure on 12 June 1997 and reached Shiriin Us (N 45.584985, E 93.440141) (Ganbaatar, 2003).

CHAPTER II. PHYSICAL GEOGRAPHY OF THE STUDY AREA, RESEARCH MATERIALS, AND METHODOLOGY

2.1 PHYSICAL GEOGRAPHY OF THE STUDY AREA

Although the research was conducted in the Great Gobi “B” Strictly Protected Area (GGBSPA) and its surrounding areas to study the reintroduced herds of wild Takhi, most of the protected area belongs to the Dzungarian Gobi. Therefore, the overview of physical geography is considered within the context of the Dzungarian Gobi.

GGBSPA hosts fauna and flora that reflect the unique characteristics of the Dzungarian Gobi. Geomorphologically, it belongs to the Central Asian province and the western sub-province of the Cis-Altai Gobi. This sub-province resembles the Trans Altai-Gobi in surface features but has numerous mountains connected to the Tian Shan system. The terrain is typically characterized by shallow depressions, low hills, eroded plains, and residual mountains. Due to strong desertification, mountain ridges are sharp, slopes steep, and exposed bedrock forms plateaus, cliffs, and steep gullies (Tsegmed, 1969).

2.1.1 Geographic Location and Terrain

The Dzungarian Gobi stretches across the southwestern edge of Mongolia, covering the southern parts of Bulgan, Uench, and Altai soums in Khovd aimag and Tonkhil and Bugat soums in Govi-Altai aimag. Oriented west to east-southeast, it is approximately 70 km wide and extends about 300 km from the national border to the Khövch Ridge. The region encompasses the following depressions, dry basins, and steppe valleys: Baruun Khuurai, Altach Dry, Bor Tsongj, Davsan Dry, Yol Khan, Takhi Us, Yolkhon Khenin Us, Khonin Us, Gun Tamga–Gashuun, as well as wide plains, gorges, residual mountains, and erosional hills. All these form the Dzungarian Gobi.

E.M. Murzaev noted that Baruun Khuurai is the eastern continuation of the Dzungarian Basin in Xinjiang (Murzaev, 1952). Baruun Khuurai Depression represents the westernmost section of the Gobi and continues eastward into Chinese territory (Selivanov, 1965). According to the “Concise Dictionary of Geographic Names of Mongolia,” “It is part of the world-famous Gobi, stretching eastward from the rear and fore of Baitag Bogd of the Altai Mountains along the foothills of Ajbogd” (Shagdar, 2000). The work *Physical Geography of Mongolia* states that the extensive arid depression east of the Mongolian Altai and Govi-Altai ranges is generally referred to as the Altai Fore-Gobi. The area is dominated by desert surfaces of dark, cracked stone, gravel, and rocky plains. The westernmost section of the Altai Fore-Gobi is the Dzungarian Gobi, also known as Baruun Khuurai Depression (Batchuluun, ed., 2020).

The Dzungarian Gobi is bordered to the north by the Mongolian Altai subranges: Gurvan Khüühed (1,752 m), Baaraan Ridge (1,846 m), Mergen (1,883 m), Nariin Khar Ridge (1,325 m), Shalyn Khar (1,701 m), Serten Khövch (1,867 m), Khalzan Ridge (2,105 m), Argaltan Ridge (2,281 m), Övchüü Serwen (2,065 m), Shiiriin Serwen (2,049 m), Khöndlön (1,978 m), Duut (2,468 m). To the east and southeast: Ulaan Khairkhan (2,125 m), Khövch Ridge (2,675 m), Yangirt Ulaan (2,162 m), Shar Sair, Bor Khatsavch Valley, Alag Uul (2,105 m), Zest Uul (2,052 m), Khengeregtiin Gorges, Ugalz Uul (2,156 m). To the south, along the

national border within the Tenger Uul system: Takhiin Shar Ridge (2,740 m), Khökh Undur Ridge (2,566 m), Ikh Khavtag (2,912 m), Baga Khavtag (2,111 m), and Baitag Bogd (3,290 m). The lowest point in Baruun Khuurai Depression ranges between 1,000–1,100 m.

Geological and Geomorphological Features

Devonian sedimentary rocks are widespread, as initially documented by V.M. Sinitsyn around Olong Bulag and later confirmed by P.S. Matrosov through fauna composition. E.E. Pavlov in Nariin Khargayt Gol, and G.P. Radchenko and N.G. Verbitskaya in Buduun Khargayt Gol, noted the occurrence of Carboniferous strata. In this area, Paleozoic Devonian and Carboniferous gray to dark-gray sandstones, siltstones, shales, siliceous layers, conglomerates, limestones, and volcanic rocks such as andesite, porphyry, and quartz porphyry are widely distributed. Coal seams may also occur within sedimentary layers (Sinitsyn, 1956).

Although the fore-Altai Gobi is generally a depression, there are residual hills and isolated mountains forming several secondary depressions. The largest is the Baruun Khuurai Depression, situated between the Mongolian Altai and Baitag subranges, measuring approximately 300 km long and over 100 km wide. Its surface is uneven, with numerous gorges, low ridges, and hollows. In the northern part, ridges are numerous; the southern part also features similar ridge structures, but in the central area, elevations range from 1,000–1,300 m, while the northern and southern edges rise to 1,000–1,500 m (Tsegmed, 1969).

According to the geomorphological regionalization of Mongolia, it belongs to the sub-province of Baruun Khuurai Depression of the Altai Fore-Gobi province within the larger Central Asian geomorphological province (Chichagov, Tsegmed, 1990). In the revised regionalization by D. Dorjgotov and D. Enkhtaivan (2009), the boundaries of geomorphological provinces and sub-provinces remain largely consistent with the 1990 classification, but the three-tiered system was simplified into a two-tiered system, placing the Baruun Khuurai Depression sub-province within the Altai Fore-Gobi province (National Atlas of Mongolia, 2009; 2022).

2.1.2 Climate

The Dzungarian Gobi is a landlocked, desert region surrounded by mountains, characterized by strong daily and annual temperature fluctuations, low precipitation, and strong winds, typical of continental extremes.

The annual mean air temperature ranges from +1°C to +3.5°C. In the coldest month (January), temperatures drop to -20°C to -24°C, while in the warmest month (July), they rise to +42.3°C, with surface soil temperatures in summer reaching +70°C. The cumulative number of days with mean daily temperatures above +10°C exceeds 3,000°C. Annual precipitation averages 39–65 mm, with 77.3% falling during the warm season. During the winter of 2009–2010, a natural disaster occurred with continuous heavy snowfall from December 30, 2009, to January 7, 2010. According to meteorological records from Bugat soum, Govi-Altai aimag, snow accumulation reached 40 cm on the plains and steppe, 60–

70 cm in the foothills and Takhiin Tal, and up to 1.0 m in higher elevations (Batchuluun, ed., 2020).

Snowmelt from winter contributes only 5–10% of the total annual precipitation. While snow accumulated on the ground during winter could potentially increase soil moisture in spring, much of it evaporates before melting. Only snow in shaded mountain slopes or within forests contributes somewhat to river flow (Tsegmed, 1969).

Mean monthly temperatures in January range from -15°C to -20°C; in July, the mean is +20°C to +25°C. The number of days with daily mean temperatures above +10°C ranges from 120–150; extremely hot days number 10–30, and extremely cold days fewer than 10. Atmospheric pressure ranges between 800–900 hPa, and prevailing winds blow from the west at an average speed of 4–6 m/s. Annually, 10–20 days experience strong winds (≥ 15 m/s), fewer than 5 days with blizzards, and 50–70+ days with dust storms. Annual precipitation is low, averaging 50–100 mm. Stable snow cover forms between November 20–December 1 and persists until March 1–10, with snow cover present on average about 100 days per year (National Atlas of Mongolia, 2022).

According to Mongolia's climate regionalization (Jambaajamts, 1989), the central part of the depression falls within the arid zone with hot summers and severe winters, while the elevated and mountainous areas surrounding the depression belong to the dry zone with cool summers and harsh winters (National Atlas of Mongolia, 1990; 2009; 2022).

2.1.3 Hydrology

Compared to the Cis-Altai Gobi, the Dzungarian Gobi has a relatively higher number of springs, wetlands, and lakes. Rivers flowing from the Mongolian Altai Mountains—such as Uench, Bodonch, Barlag, Övchüü, and Bijii—enter the Baruun Khuurai, Bor Tsongj, Yolkhon Khenin Us channels, and Khonin Us Gobi. Most of these rivers originate from springs and carry little water, often disappearing into sandy deposits shortly after leaving the mountains (Tsegmed, 1969).

Small rivers such as Tsagaan, Takhilt, and Bogd, flowing along the western slopes of the Khövch Ridge, feed the wetlands of Gun Tamga–Gashuun. Rivers originating from the rear of Baitag Bogd, including Tsagaan Burgast, Buduun Khargait, Nariin Khargait, Khujirt, and Uliastai, disappear into the mountain foothills.

Springs, wetlands, and water points of the Dzungarian Gobi, listed from west to east, include: Nokhoi Dolookh, Shaakhayt, Udiin Us, Bakhant's bulguud, Uushgiin Aman Us, Havtsal's headwaters, Uushgiin Us, Ekhen Us, Buduunii Us, Damjingiin Us, Zeeren Bulag, Gashuun Us, Khulstain Us, Shiiriin Us, and in the southern section: Looiroin Bulag, Nuuts Us, Sukhain'tin Us, Gashuun Us, Zeegiin Us, Jügentiin Us, Tomtiin Us, Khar Tolgoi, Havchig, Zeeren, Nariin Bulguud, Tsargiin Us, Argali Shand, Yargaitin Us, Tavan Ovoo, Khairkhan. In the central part: Khood, Elsen Us, Zadgai'tin Us, Argali Shand, Takhiin Tsavchaal, Yolkhon's wetland, Bosgo Us, Gashuun Us, Takhiin Us wetland, Khonin Us wetland (Naimaa, ~2 km; Tögrog, Tol, Shagshig, Upper Edge, Lower Edge springs, etc.), Todogiin Us, Gun Tamga (6–8 km), Gashuun, and Shiiriin (Khöndlön) bulguud. In addition, humans and livestock rely on

hand-dug wells for water supply. Groundwater and precipitation serve as the main sources of water.

Yolkhon wetland contains several small lakes, mostly dependent on annual precipitation. The largest, Yolkhon Lake, is located in Altai soum, Khovd aimag, at 1,032 m elevation (N 45°31'51.9", E 92°16'00.5"). The lake lies in a depression surrounded by reeds (*Phragmites australis*) and low hills. According to satellite imagery from the project "*Improving Water Management in Section B of GIDZP*", the lake covers 36.06 ha, with a length of 1,300 m and width of 450 m, shallow (0.5–0.7 m), with muddy-sandy substrate. Algae, moss, and filamentous aquatic plants are abundant, giving the water a greenish tint. Dissolved microelements measure 10.82 mg/L (~140%), and water temperature is 22.1°C (Ayuushsüren, 2020; SDC, ITG, 2021).

The main river and its tributaries (and lakes) form the river basin; the Uench–Bodonch basin falls within this category, and these rivers are classified as "small rivers" based on discharge (Davaa, 2015). Hydrologically, the area belongs to the endorheic basins of Central Asia (National Atlas of Mongolia, 2022).

2.1.4 Soil

Mongolia's geographical location, topography, depressions and elevations, climate, and latitudinal position are primary factors influencing soil characteristics and geographical distribution (Batchuluun, ed., 2020). The Dzungarian Gobi belongs to the desert zone with brown-gray soils. By soil classification, it exhibits features of rare desert soils and desert brown soils, as well as extremely arid brown desert soils (Dorjgotov, 2003).

O. Batkhishig (2013) developed a revised classification of Mongolian soils for alignment with international standards and contemporary research. According to this classification, the Dzungarian Gobi soils are represented by brown-gray and brown desert types (Batkhishig, 2016), largely consistent with previous classifications.

In the Dzungarian Gobi, soils of valleys, hills, plains, and depressions include: brown soils with thin rare layers, light brown soils of rare desert type, brown-gray soils of thin layer, brown-gray desert soils, extremely arid brown desert soils, saline meadow soils of lowlands, and sandy accumulations. Surrounding mountains feature mountain brown soils, rare brown mountain soils, and light brown mountain soils. Wind erosion is significant, while water erosion is moderate, and surface wash-off is widespread. According to Mongolia's soil-geographical regionalization (Dorjgotov, 2009), the area belongs to the western province of Mongolia, in the Baruun Khuurai circle of the Gobi major province (National Atlas of Mongolia, 2009; 2022).

2.1.5 Vegetation

The Dzungarian Gobi is a mountain-enclosed, arid, low-precipitation region with a distinctive desert vegetation composition. Here, vegetation of desert and saline soils prevails, with steppe vegetation appearing in some surrounding mountain areas. Desert vegetation is subdivided into reed desert, steppe-desert, true desert, and hyper-arid desert sub-types (National Atlas of Mongolia, 2009; 2022). Each is detailed as follows:

Reed Desert: On low mountains, hills, and plains: *Agropyron nevskii*, *Stipa glareosa*, *S. gobica*, *Caragana pygmaea* in steppe-desert communities of the Odlog-Khulgana-Nevskii region; white saxaul-grass associations (*Stipa glareosa*, *Nanophyton grubovii*, *Artemisia gracilescens*) on plains and hills.

Steppe-Desert: Plains, hills, and undulating terrain: *Krascheninnikovia ceratoides*, *Kochia prostrata*, *Nanophyton grubovii*, *Stipa glareosa*, *Artemisia gracilescens*, *Anabasis brevifolia*, *Reaumuria soongarica*, in mixed steppe-desert associations.

True Desert: Hills and plains: *Krascheninnikovia ceratoides*, *Artemisia terrae-albae*, *Anabasis salsa*, *A. truncata*, *Haloxylon ammodendron*, *Salsola arbuscula*, *Zygophyllum xanthohylon*, *Ephedra przewalskii*, *Anabasis brevifolia*, *Salsola passerina*.

Hyper-Arid Desert: Hills and plains: *Haloxylon ammodendron*, *Anabasis aphylla*, *Ephedra przewalskii*, *Iljinia regelii*.

In Baruun Khuurai, Bor Tsongj, and Yolkhon depressions: saline vegetation with *Phragmites communis*, *Tamarix ramosissima*, and *Halimodendron halodendron*.

On Baitag Bogd Mountain: medium and low mountains support meadow and shrub-steppe vegetation, including *Helictotrichon schellianum*, *H. desertorum*, *Carex pediformis*, *Colurea geoides*, *Scabiosa ochroleuca*. On Khövch Ridge: steppe vegetation with *Agropyron cristatum*, *Festuca valesiaca*, *Artemisia gracilescens*. On Takhiin Shar Ridge and Mongolian Altai subranges: steppe-desert vegetation with *Agropyron nevskii*, *Stipa glareosa*, *Krascheninnikovia ceratoides*, *Caragana leucophloea*.

Floristic Composition: Vegetation in the Dzungarian circle represents a mixture of Gobi, Northern Turanian, Dzungarian, Mongolian Altai–Gobi, and Mongolian Altai–Dzungarian floristic provinces. Representatives of southern Siberia, such as secondary elements of newly formed forests, are present (Olziihutag, 1989). Within the circle, 329 species across 70 families are recorded, including 20 endemic and 58 subendemic species (Baasanmunkh et al., 2022). Families richest in species include Compositae (153 species), Fabaceae (77), Chenopodiaceae (69), Poaceae (68), and Caryophyllaceae (54), forming the core of regional plant diversity. The Baitag Bogd area is particularly rich in species, with 48% (440 species) represented by vascular plants (Baasanmunkh et al., 2021).

According to Red List criteria, the area contains 6 endangered, 26 potentially endangered, 57 vulnerable, 7 rare, 26 least concern, and 7 data-deficient plant species (Nyambayar et al., 2014; Oyuntsetseg et al., 2018; Urgamal et al., 2019; Baasanmunkh et al., 2021).

In the Dzungarian Gobi, *Elaeagnus angustifolia* groves—the only representative of tree vegetation in the arid Central Asian zone—are found in Bayan-Ovoo, Elgen Us, and Yolkhon ravines, reaching 8–12 m in height, 40–60 cm in diameter, with around 2,500 individual trees (Haulenbek, 2007).

According to Mongolia's vegetation-geographical classification, the area belongs to the Eurasian conifer and meadow-steppe major province, Central Asian dry sub-province, Khövch Ridge circle, Baitag Bogd–Ikh Khavtag circle, and the Sahar–Gobi desert major province, Turanian sub-province, Baruun Khuurai circle (Bayasgalan; National Atlas of Mongolia, 2022).

2.1.6 Fauna

The Dzungarian Gobi is dominated by desert mammal communities, including xeric steppe and desert wetland habitats. Bird, amphibian, and reptile fauna are also typical of desert ecosystems, with a high proportion of rare, endangered, and endemic species.

This Gobi forms part of the historical range of the Przewalski's horse (*Equus ferus przewalskii*), dhole (*Cuon alpinus*), and saiga antelope (*Saiga tatarica tatarica*, extinct locally), as well as of the Asian badger (*Meles leucurus*), Gobi bear (*Ursus arctos gobiensis*), and wild Bactrian camel (*Camelus ferus*). It is also the westernmost core habitat of the Mongolian wild ass (*Equus hemionus*) and goitered gazelle (*Gazella subgutturosa*).

Endemic species restricted to the Dzungarian Gobi include Pewzow's toad (*Bufo peszewi*), the Horned Toad lizard (*Phrynocephalus helioscopus*), steppe racerunner (*Eremias arguta*), Dzungarian racerunner (*Eremias dzungarica*), yellow souslik (*Eolagurus luteus*), Tamarisk gerbil (*Meriones tamariscinus*), small five-toed jerboa (*Allactaga elater*), and Dzungarian three-toed jerboa (*Stylodipus sungorus*).

Within the Gobi, one amphibian species, 10 reptile species, and 55 mammal species have been recorded. Of these, one cervid, one insectivore, four chiropterans, two lagomorphs, 28 rodents, 13 carnivores, two ungulates, and four lagomorph-like species are present (Batsaikhan et al., 2014; 2022; Gombobaatar, 2019).

The most recent monitoring recorded 210 bird species across 20 orders and 46 families: Anatidae 20, Phasianidae 2, Pelecaniformes 2, Gruiformes 1, Columbidae 5, Falconiformes 13, Accipitridae 13, Falconidae 5, Gruidae 5, Charadriiformes 32, Strigiformes 1, Columbiformes 5, Coraciiformes 1, Piciformes 4, Passeriformes 108 species (Bayanmunkh, 2025).

In the southern branches of the Mongolian Altai, at the lower reaches of the Duut and Bij rivers, Przewalski's gazelle has been recorded (ITG "B" Zone Reports, 2010; 2013).

According to Mongolia's faunal-geographical classification, the area belongs to the Western Khuurai circle of the Gobi province for birds, and to the Western Khuurai circle of the Gobi sub-province within the Mongol-Tibetan province for mammals (Boldbaatar; National Atlas of Mongolia, 2022).

2.1.7 Landscape

The Western Khuurai depression is geographically isolated from other parts of Mongolia, though it connects naturally to the adjacent Dzungarian Gobi, influencing its landscape. In the lower-lying areas, the depression's effect is pronounced, with salt-marsh flats, seasonal ponds, and hyper-arid continental desert scattered across the terrain.

In the central depression, desert landscapes with reed-saltbush vegetation (*Stipa-Krascheninnikovia*) predominate, while at higher elevations and mountain foothills, desert-steppe vegetation typical of Turanian-Dzungarian deserts develops. Rising from foothills to peaks, landscapes transition through northern desert, sparsely vegetated desert, and desert-steppe conditions, culminating in high-altitude mountain belts of Altai dry steppe and alpine meadows (Sanjmyatav, 2011; Batchuluun, ed., 2020).

The Dzungarian Gobi exhibits both zonal (broad landscape belts) and intrazonal (sub-belt) characteristic landscapes, reflecting its climate, topography, soil, and vegetation (Dash; National Atlas of Mongolia, 2009; 2022). These include:

Zonal Landscape Characteristics:

- Southern Mongolian Altai subranges, Khövch Ridge, and Baitag Bogd: desert-steppe landscapes with brown soils, sparse shrub-grass vegetation (*Stipa-Krascheninnikovia*).
- Lower depressions and adjacent mountains: desert landscapes with brown soils, sparse shrub-grass vegetation (*Krascheninnikovia-Anabasis, Stipa-Kochia*).
- Gobi-Altai foothills and southern plateaus: brown-gray soils, desert-shrub vegetation (*Anabasis, Haloxylon*).
- Low mountains and highlands of the Dzungarian Gobi: extremely arid brown desert soils, sparse shrub vegetation along seasonal channels and rocky areas (*Haloxylon, Zygophyllum*).

Intrazonal Landscape Characteristics:

- Western Khuurai, Bor Tsongj, Davsan Khurai, Yolkhon, and Khonin Us: depression floors with salt-marsh soils, saline vegetation, and gypsum-salt complexes (*Haloxylon-Anabasis*) (Zag-Budarghant Complex).

2.1.8 Study Area and Location

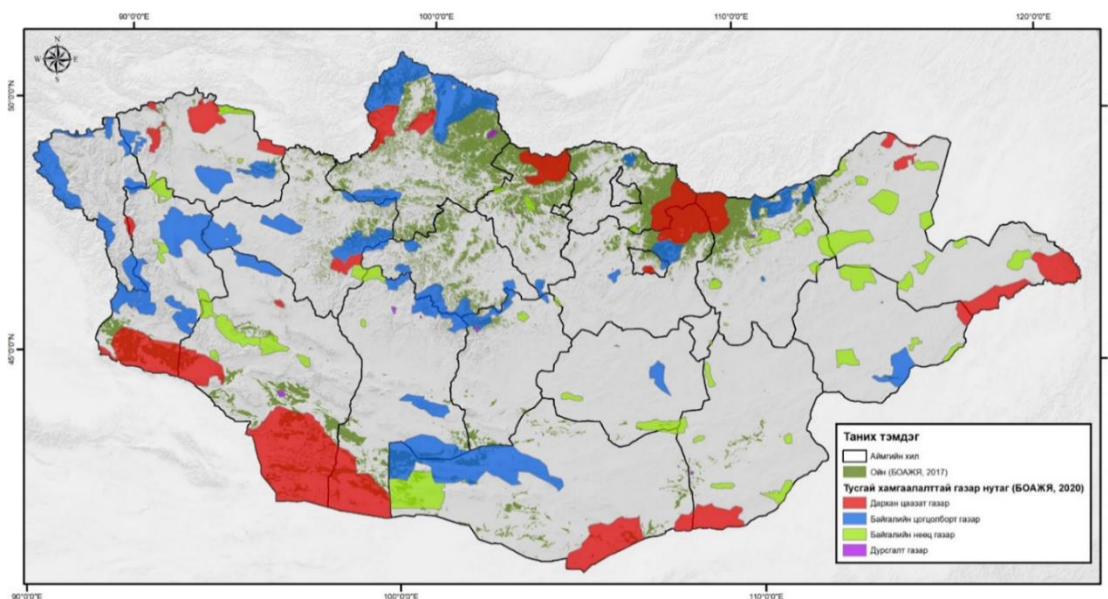
The Great Gobi Strictly “B” Protected Area (GGBSPA) is located in the southwestern part of Mongolia, on the leeward side of the Altai Mountains. It encompasses the southern parts of Bugat and Tonkhil soums of Gobi-Altai province and Altai, Üench, and Bulgan soums of Khovd province, along the Mongolia–China border.

Located in the northern part of Central Asia’s great desert and within the Dzungarian Gobi ecosystem, this zone was established in 1975 by the People’s Great Khural of the Mongolian People’s Republic (Resolution No. 84) as the Great Gobi Strictly Protected Area with two zones, “A” and “B,” to preserve ecosystem balance, protect the habitats of wild fauna and flora listed in both international and Mongolian Red Lists, and ensure sustainable development.

Following the adoption of the new law on Strictly Protected Areas, the Mongolian Parliament (Resolution No. 26, 1995) retained the “A” and “B” zones under the slightly modified name “Great Gobi Strictly Protected Area.” To fully conserve the unique ecosystem of the Dzungarian Gobi, support the growing Przewalski’s horse population, and protect its habitat, the boundary of the “B” zone was expanded on May 2, 2019, under Resolution No. 41 of the Parliament (<https://legalinfo.mn/mn/detail?lawId=14402>), encompassing a total area of 1,835,724 hectares (Figure 1).

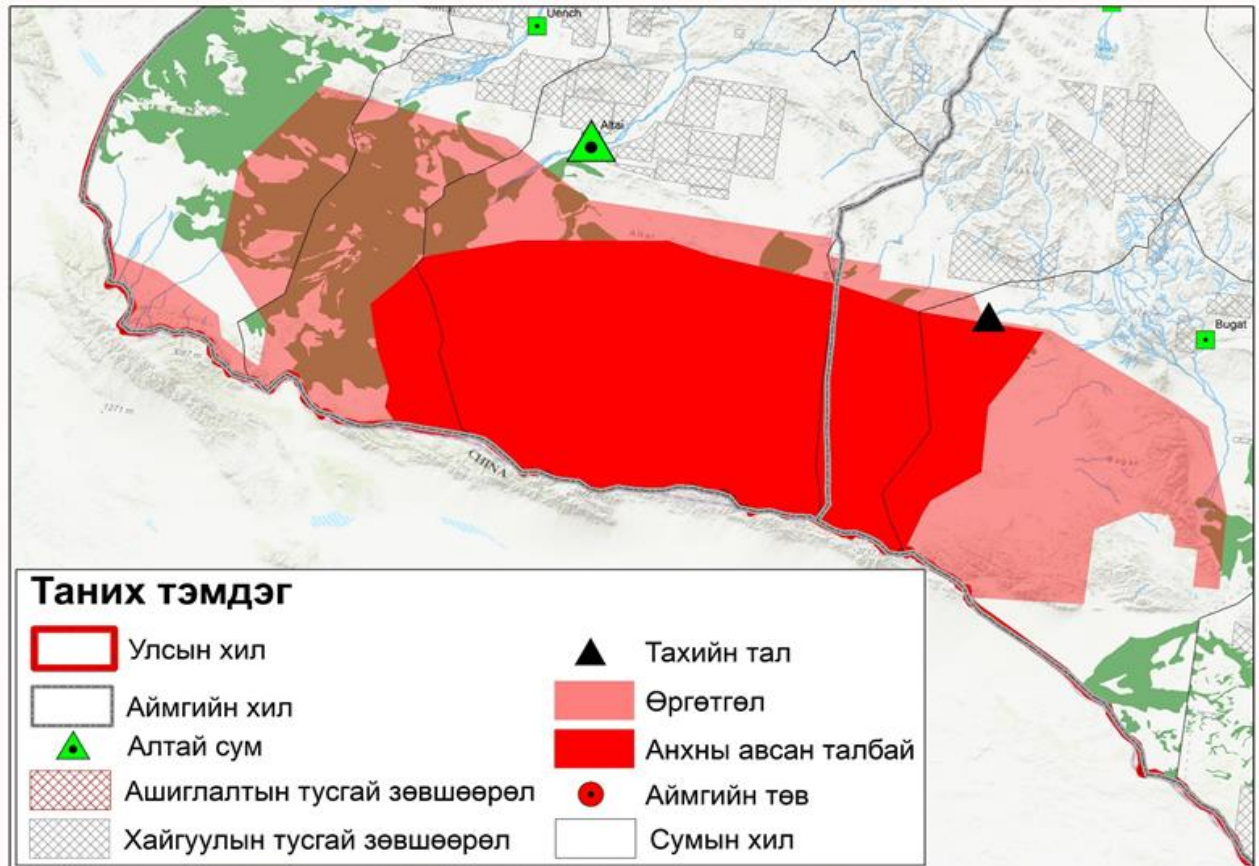
Study Period:

The study was conducted from May 1, 2022, to March 31, 2025, with funding from the International Takhi Group, in collaboration with the Great Gobi “B” Strictly Protected Area (GGBSPA) administration, 21 rangers, and fieldwork supervisor O. Ganbaatar. Data on herd structure, births, mortality, distribution, and movement patterns of the takhi were recorded and collected following the standard two-method protocol. I personally conducted fieldwork over a period of 9 months and 3 days.



(Figure 1: Boundaries of the GGBSPA).

Figure 2. Boundary of the Great Gobi "B" Strictly Protected Area



2.2. Research Materials and Methodology

2.2.1 Field Research Methodology

Field monitoring to determine the growth, mortality, herd changes, and distribution of the takhi was carried out according to the approved routes (from 2023) using a grid-based map system, observation and recording (since 2002), and the Smart program. The work was implemented by 21 rangers from April to September using motorcycles and from October to March using vehicles.

Field research employed data sheets, notebooks, pencils, Vortex Copperhead HD 10×42 binoculars, and 20–60× ATS 65 telescopes. Takhi were photographed using Canon D80 and EOS 7D cameras with Canon 100–400mm and Nikon 75–300mm lenses. On one side of the data sheet was a 1:100,000 grid map, and on the other side a standard table. Each herd encountered on a given day, including its composition, number, additions, losses, foals, and deceased individuals, was recorded row by row, and the location points were numbered and marked on the map (Figure 3).

Figure 3. Grid Map

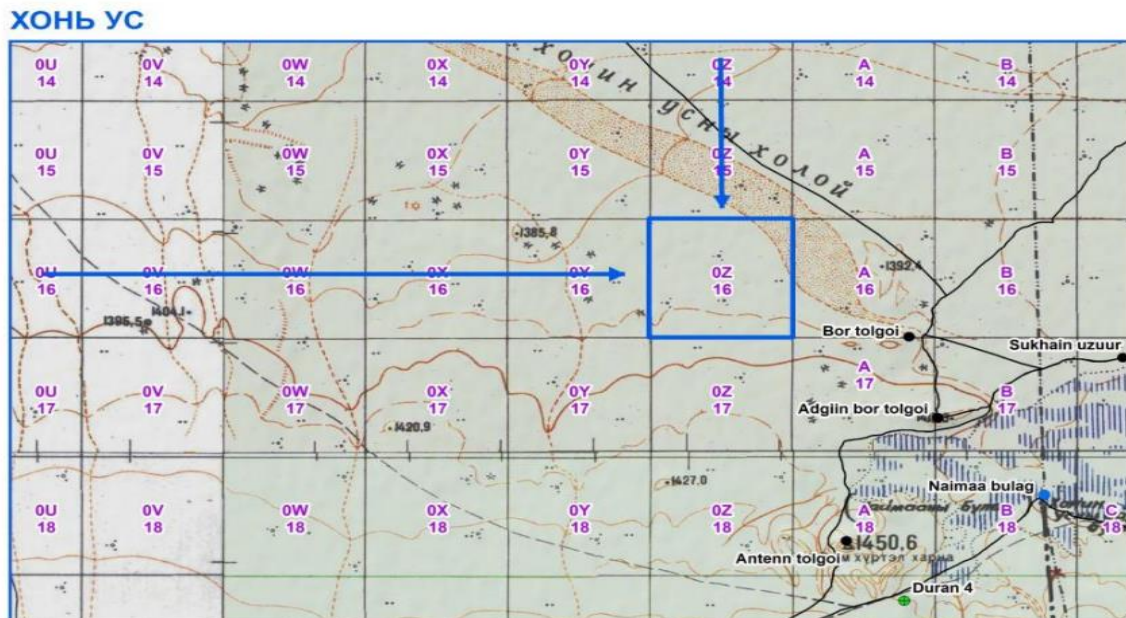


Figure 4. Table and Photograph of Observed Takhi Data

	Who observed	Date	Time	Group name	Place name	Position			Takhi number		Distance	Comment	
						letter	Number	X	Y	Adult			Foal
3	Osohbayr	2023.08.02	11:30	Takhi	Anten tolgoi	A	18	93.778436	45.320607	5	200		
4	Osohbayr		13:43	Takhi	Deed shagshig	E	16	93.217176	45.359059	22	1000		
5	Osohbayr		13:43	Takhi	Deed shagshig	E	16	93.217176	45.359059	46	1000		
6	Osohbayr		13:43	Takhi	shiriin us	L	4	93.397438	45.574602	11	50		
7	Dagwasuren	2023.08.04	11:10	Takhi	Tamgiin am	W	21	93.675728	45.267252	10	400		
8	Dagwasuren		11:10	Takhi	Tamgiin am	W	21	93.675728	45.267252	6	500		
9	Dagwasuren		11:10	Takhi	Tamgiin am	W	21	93.675728	45.267252	2	1	500	
10	Altansukh	2023.08.05	7:30	mazaalai	Deed shagshig	E	17	93.880778	45.337866	10	600		
11	Lhagwa		7:30	Takhi	Deed shagshig	E	17	93.880778	45.337866	3	600		
12	Lhagwa		7:30	Takhi	Deed shagshig	E	17	93.880778	45.337866	6	600		
13	Lhagwa		7:30	Manuul	Deed shagshig	E	17	93.880778	45.337866	11	600		
14	Lhagwa		7:30	Takhi	Deed shagshig	E	17	93.880778	45.337866	5	600		
15	Lhagwa		7:30	ugalz	Deed shagshig	E	17	93.880778	45.337866	10	1	600	
16	Lhagwa		7:30	Stallon	Deed shagshig	E	17	93.880778	45.337866	29	600		
17	Lhagwa		7:30	Takhi	Deed shagshig	E	17	93.880778	45.337866	15	600		
18	Lhagwa		8:02	Takhi	Naimaa bulag	B	18	93.803952	45.320430	5	300		
19	Lhagwa		8:30	Takhi	Tal bulag	D	18	93.854984	45.320059	6	400		
20	Ganbataa	2023.08.07	7:50	Takhi	Deed shagshig	E	17	93.217107	45.341056	5	600	НҮБ судалгаа	
21	Lhagwa		8:00	Takhi	Deed shagshig	E	17	93.217107	45.341056	10	1	700	
22	Togsbaatar		8:00	Takhi	Deed shagshig	E	17	93.217107	45.341056	27	700		
23	Natasha		8:00	Takhi	Deed shagshig	E	17	93.217107	45.341056	4	600		
24	Monkh tamir		8:10	Takhi	Deed shagshig	E	17	93.217107	45.341056	11	200		
25	Monkh tamir		8:20	Takhi	Deed shagshig	E	17	93.217107	45.341056	2	200		
26	Monkh tamir		8:25	ugalz	Deed shagshig	E	17	93.217107	45.341056	10	1	200	
27	Monkh tamir		8:30	Takhi	Deed shagshig	E	17	93.217107	45.341056	6	200		
28	Monkh tamir		8:35	noyon	Deed shagshig	E	17	93.217107	45.341056	9	200		
29	Monkh tamir		9:20	Takhi	Deed shagshig	B	18	93.803952	45.320430	5	200		

2.2.2 SMART Program Methodology

In recent years, in Protected Areas (PAs) in Mongolia, monitoring has shifted from reporting only on paper to integrating daily field activities electronically, creating a centralized database. In this context, the **SMART (Spatial Monitoring and Reporting Tool)** program has been implemented.

Key features of the SMART program:

- Enables rangers to conduct monitoring in specific areas, collecting observation and other data.
- Collected data can be entered into the program, integrated, analyzed, used to define objectives for future monitoring, and reported.
- A comprehensive management system based on mobile phones, desktop computers, and online platforms that allows all stakeholders—rangers, PA administration, NGOs, the public, and authorities—to participate equally.
- Supports the effective protection of biodiversity by centralizing, processing, and managing necessary data.

Global and national implementation of SMART:

- As of 2023, the program is implemented in over 1,100 sites across more than 95 countries worldwide.
- 18 countries have formally integrated SMART into their legal and regulatory framework.
- In Mongolia, the Ministry of Environment and Tourism approved the SMART program manual and methodology on **June 23, 2023, via Order A/219**.

Data collection requirements and process:

- Can be installed and used on mobile devices.
- Data collection requires a network connection at the start and end of monitoring, but no network is needed while in the field.
- Steps:
 1. Initiate monitoring, selecting the team leader or members, objectives, and starting location.
 2. During the route, record observation points of animals (filling in species name, male/female, offspring, total count).
 3. Pause or end the route as needed.

Usage of collected data:

- Data collected in SMART can be visualized, and it is possible to map only the points where Przewalski’s horses were observed.

Figure 5. SMART Program: Starting and Ending Monitoring Sessions

← Sighting

45° 32' 18.7" N, 93° 39' 3.4" E, 1.009 mi

Start patrol

Leg	# - 0 ft
Эргүүлийн тээврийн хэрэгслийн төрөл	Авто машин
Баг	Хонин усны баг
Хяналтыцн цэг	Хонин ус
Үүрэг	Мониторинг судалгаа
Зорилго	Takhi
Ажилчид	Hurlee O, Penelope V, Алтансүх Нанжид
Ахлагч	Алтансүх Нанжид
Машины дугаар	7585

← Эргүүл эхлүүл ✓

* Байршил
47° 55' 11.6" N, 106° 55' 19.0" E

* Эргүүлийн тээврийн хэрэгслийн төрөл

* Зэвсэглэсэн

Баг

Хяналтыцн цэг

* Үүрэг
Хэсгийн хяналт шалгалт

Зорилго

Тайлбар

* Ажилчид
Байгаль хамгаалагч 1, Байгаль хамгаалагч 2, Байгаль хамгаалагч 3

* Ахлагч
Байгаль хамгаалагч 1

Figure 7. Distribution of Przewalski's Horses in the SMART Program

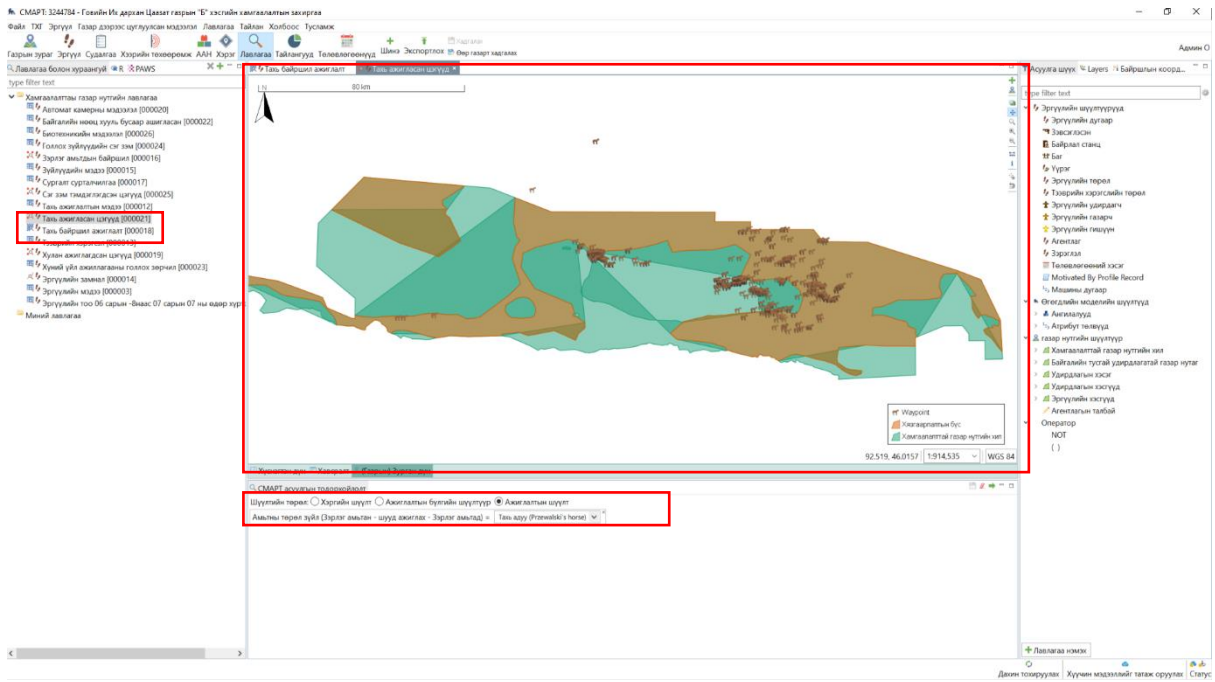
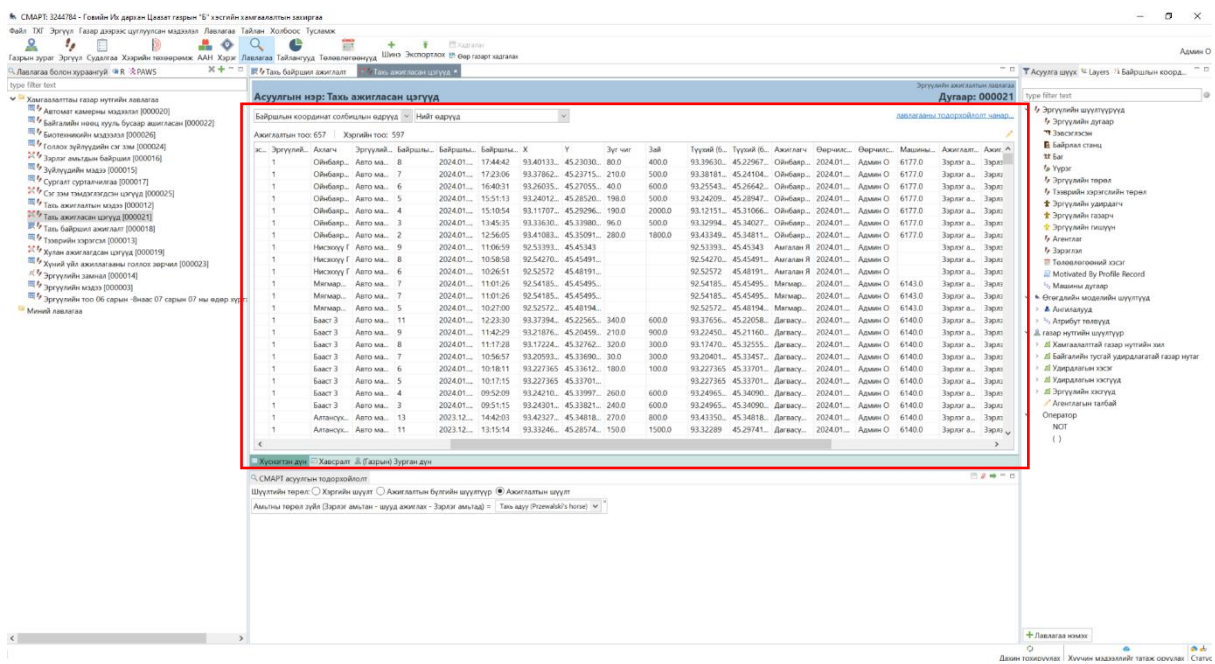


Figure 8. Observational Data of Przewalski's Horses in the SMART Program



2.2.3 Data Processing

The Przewalski's horse monitoring survey was conducted from May 1, 2022, to March 31, 2025. A total of 8,227 point observations were collected, including 5,547 from field observations and 3,723 from the SMART program. The distribution and habitat areas were analyzed using ARCGIS software, while Excel was used to process data on herd composition, births, and mortalities. Within the context of factors affecting population size, population counts were compared using the dzud (severe winter) index, calculated according to Government Resolution No. 286.

Calculation of Population Growth/Decline

The annual population growth rate (r^t) was calculated using the formula:

$$(r^t) \quad r^t = \left(\frac{n^t - n^{t-1}}{n^{t-1}} \right) * 100\%$$

Where:

- n^t = total population in the current year
- n^{t-1} = total population in the previous year

Dzud Index Calculation

Seasonal climate conditions were assessed using monthly average air temperatures and total precipitation data from 48 meteorological stations uniformly distributed across Mongolia. The following parameters were calculated:

- Summer and winter temperatures, precipitation

(T_{summer} , P_{summer} , T_{winter} , P_{winter}), Temperature difference between summer and winter ΔT , Drought/summer index (calculated as the difference between normalized deviations of summer temperature and precipitation (S_{summer}), Winter harshness index (S_{winter}), calculated as the difference between normalized deviations of winter temperature and precipitation Dzud index S_{dzud} calculated as:

$$S_{dzud} = S_{summer} - S_{winter}$$

In the formula, the larger the value of the disaster/winter mortality index $S_{dzud} \gg 0$, the more severe the summer drought and the harsher the winter. If, during summer, the temperature anomaly is warmer than the long-term mean $(T_{summer} > 0)$, and precipitation is below the long-term mean $(\Delta P_{summer} < 0)$, the summer is droughty/drier ($S_{summer} > 0$). Conversely, if summer is cooler than the mean ($\Delta T_{dzud} < 0$), and precipitation is above the mean ($\Delta P_{summer} > 0$), the summer is favourable ($S_{summer} < 0$). If winter is warmer than the mean ($\Delta T_{winter} > 0$) and snowfall is low ($\Delta P_{winter} < 0$), the winter is relatively benign ($S_{winter} > 0$). Whereas if winter is colder than the mean ($\Delta T_{winter} < 0$) and snowfall is high ($\Delta P_{winter} > 0$), the winter is correspondingly severe ($S_{winter} < 0$) (Mönkhbat, 2024).

1.3.1 Calculation of the Population Growth Rate of Przewalski's Horse

$$\text{Reproductive rate (\%)} = \frac{\text{number foaled mares}}{\text{number of foaling-capable mare}} * 100\%$$

$$\text{Survival rate (\%)} = \frac{\text{number of survived foals}}{\text{total foals number}} * 100\%$$

$$\text{Annual growth rate (\%)} = \frac{\text{End-of-year count} - (\text{Beginning-of-year count} + \text{Newly introduced individuals})}{\text{Beginning-of-year count} + \text{Newly introduced individuals}} * 100\%$$

(Chen et al., 2008).

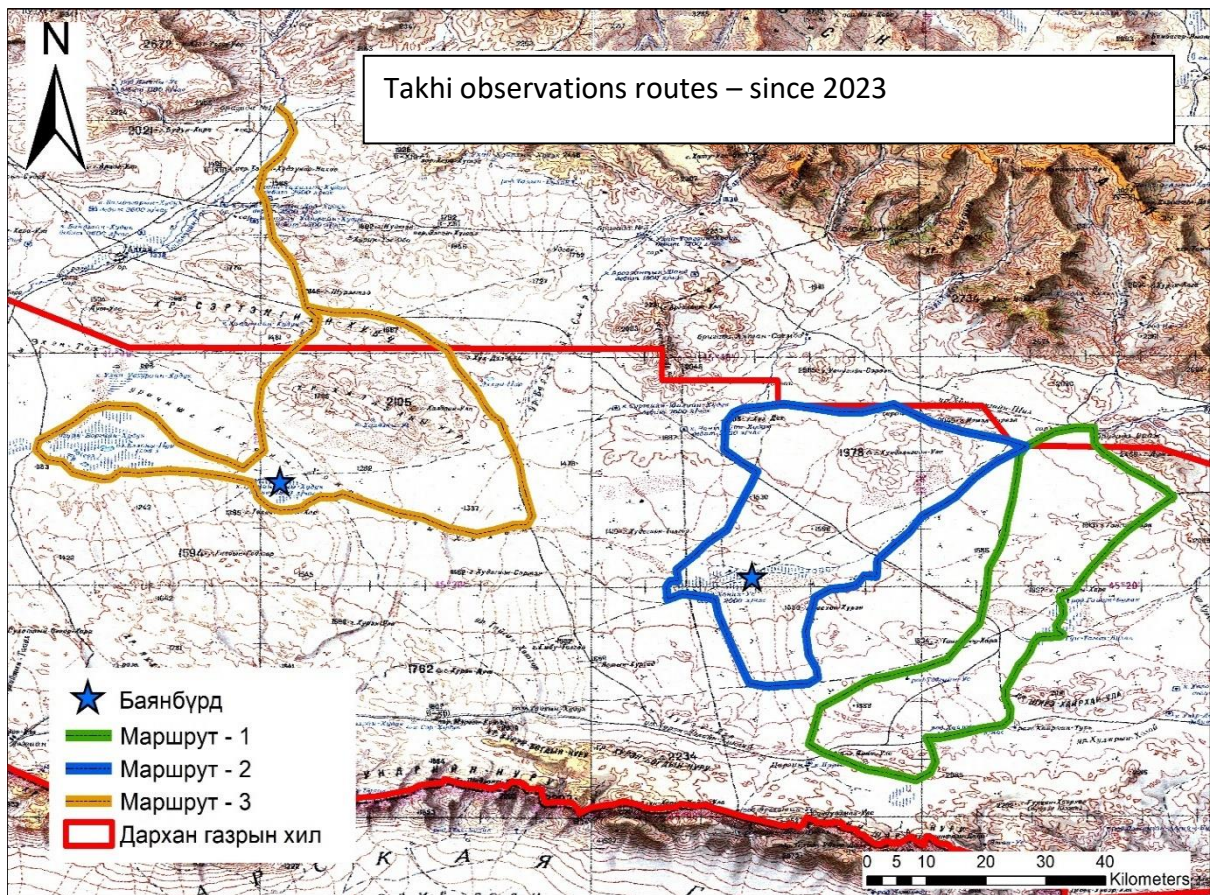
1. III. RESULTS

3.1 Methodology for Estimating the Population Size of Takhi

Based on the population monitoring methodology of Takhi, since 2023 the herds have been classified as follows:

1. By reproductive and non-reproductive harems (stallion, bachelor groups, young, sex)
2. By the number of individuals in the herd
3. By the number of foals
4. By geographical location
5. By behavior (wild, tame)
6. By distinctive external features
7. Identification of individual Takhi at the individual level

Figure 8. Takhi observation routes



Based on the areas where Takhi are likely to be observed, the monitoring routes were updated and divided into three groups in the directions of Khoni Us, Guntamga, and Takhi Us. Observations were conducted accordingly.

Route 1. Research Camp – Ulaanbulag – Gashuun Us – Guntamga – Khairkhan Bulag – Tavan Ovoo – Yargait – Aguit – Toodog – Tangadiin Khar – Chinbaaz – Khaltaryn Tolgoi – Research Camp

Route 2. Research Camp – Tavan Tolgoi – Khooloin Tolgoi – Tovkh – Tsemtsseg – Yeekher – Maimaa Bulag – Adgiin Bor Tolgoi – Ögöömр – Goviin Elsen Tolgoi – Nukhen – Khukh Del – Shiriin Us – Research Camp

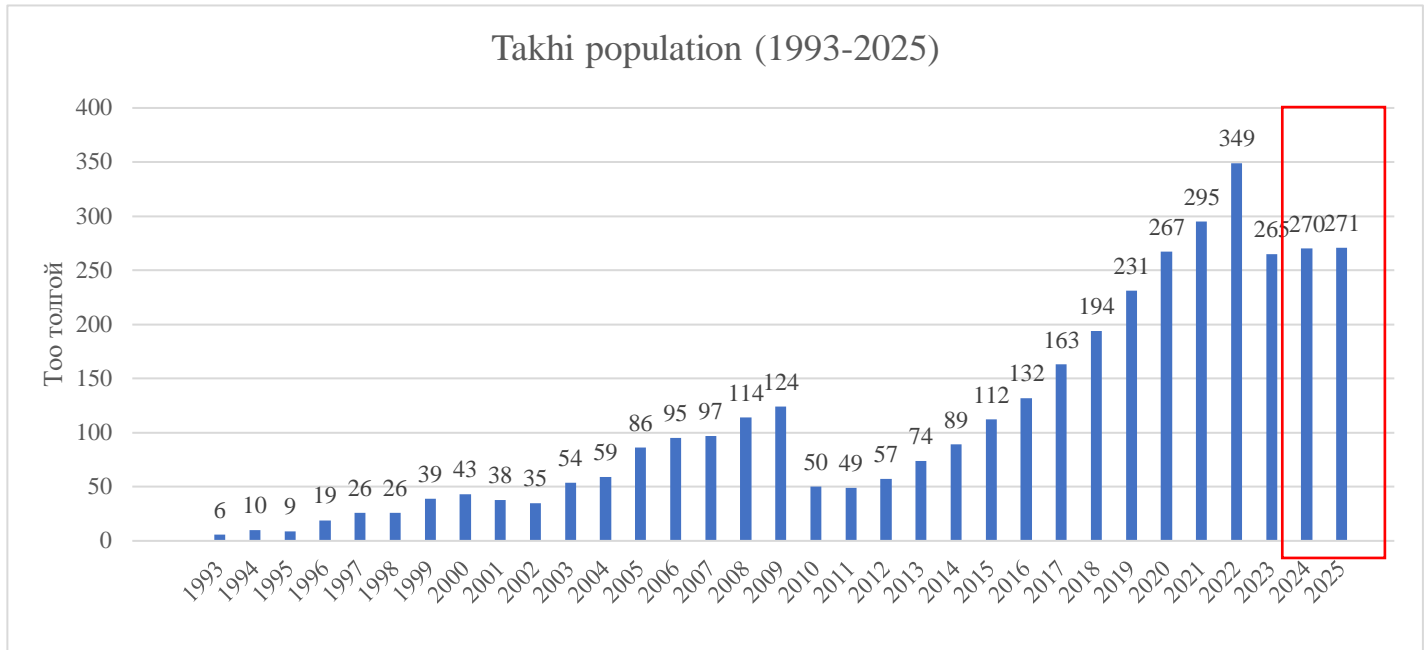
Route 3. Altai souм – Serten – Khalzan Bүrgeп – Gashuun Us – Bosgo Us – II Us – Shanaga Us – Takhi Us – Takhi Usnii Khar Tolgoi – Ulaanganga – Khalzan Bүrgeп – Altai souм

Thus, the Takhi monitoring study was implemented along these three main routes.

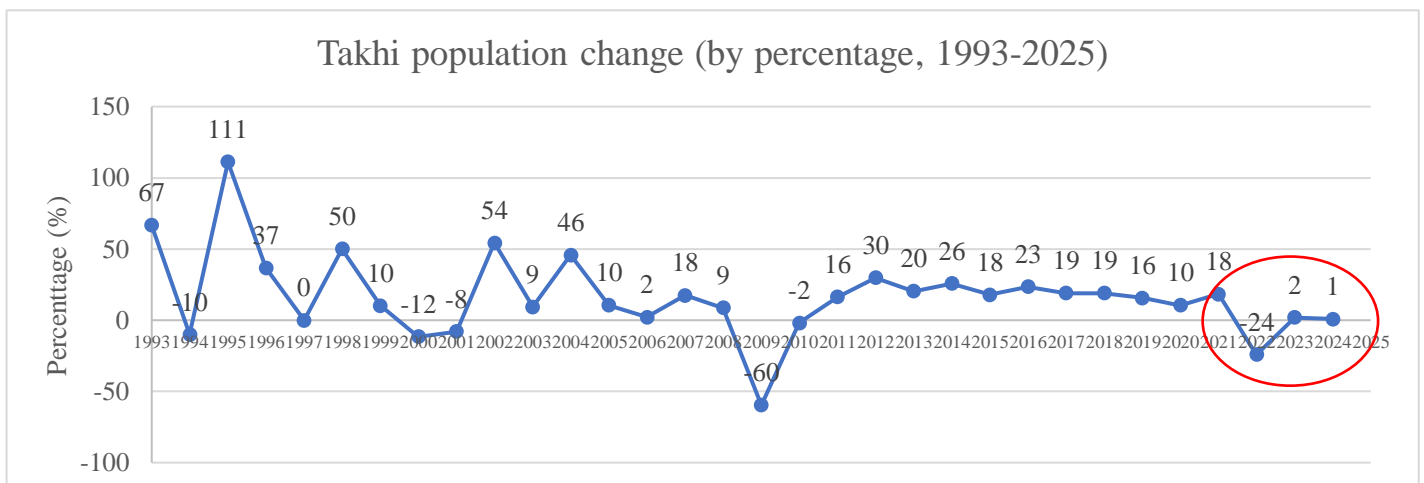
3.2 Population Size and Dynamics

As of March 31, 2025, a total of **271 Takhi** were recorded. Of these, there were **29 breeding harems** and **55 bachelor stallions**. By distribution, **201 Takhi** were registered around the Khoni Us oasis, **59 Takhi** around the Takhi Us oasis, and **11 Takhi** in Khashaa.

Graph 1. Population Size and Dynamics of Takhi /1993-2025/

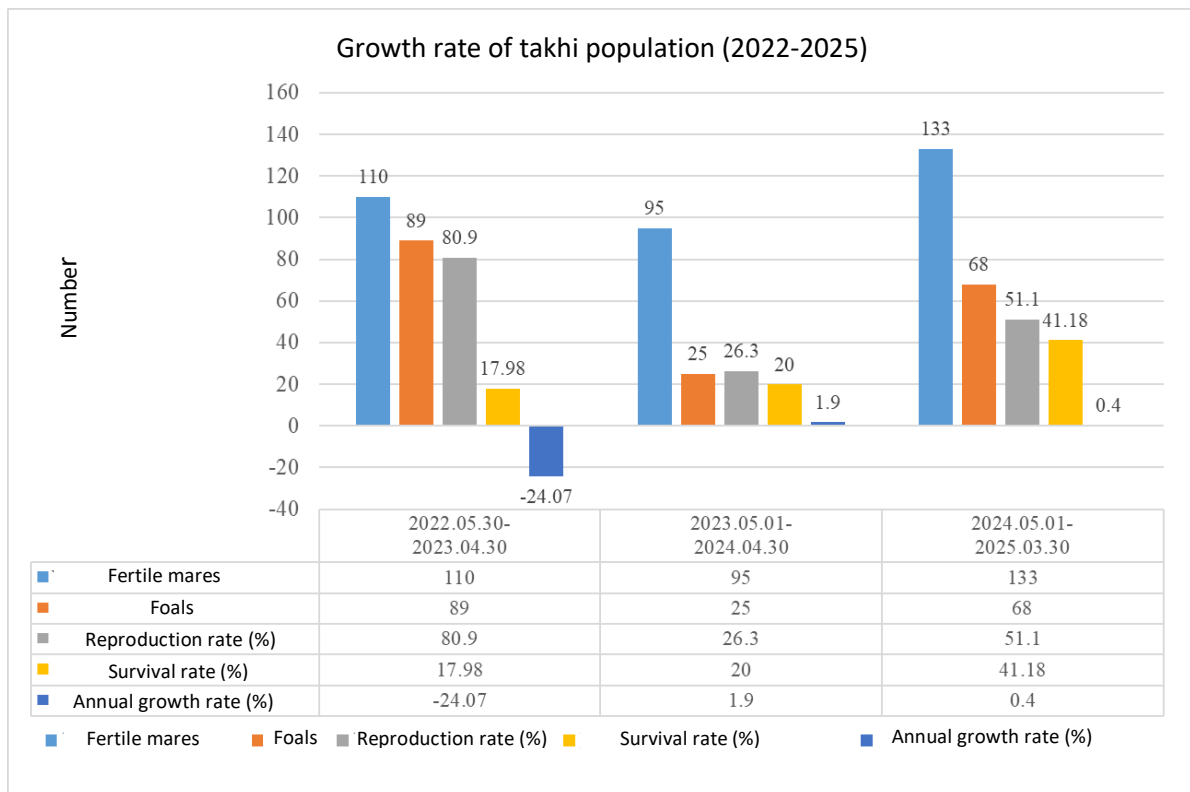


Graph 2. Increase and Decrease of Takhi Population (savethewildhorse.org) (%), 1993-2025)



Over the past three years, the population size has remained stable, with no observable increase. When considering the numerical indicators from the previous graph (No. 1) in percentage terms, there was no case in which the annual growth rate was less than two percent for three consecutive years

Figure 3. Annual growth rate of the Takhi (Przewalski's horse) population, 2022–2025



In the year following a dzud, the number of breeding mares, foal births, reproductive rate, foal survival rate, and annual growth rate all decreased. However, for 2024–2025, although all these indicators increased, there was no net annual population growth..

Figure 4. Takhi (Przewalski's horse) population and mortality/decline trends (2022-2025)

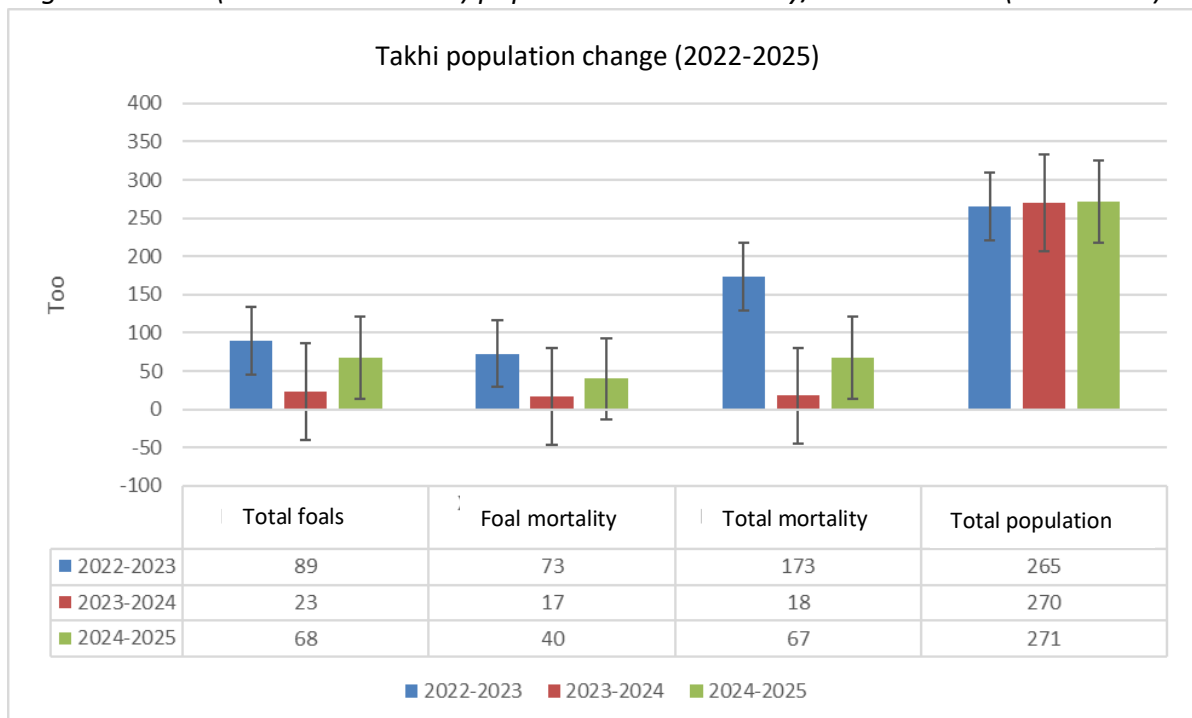
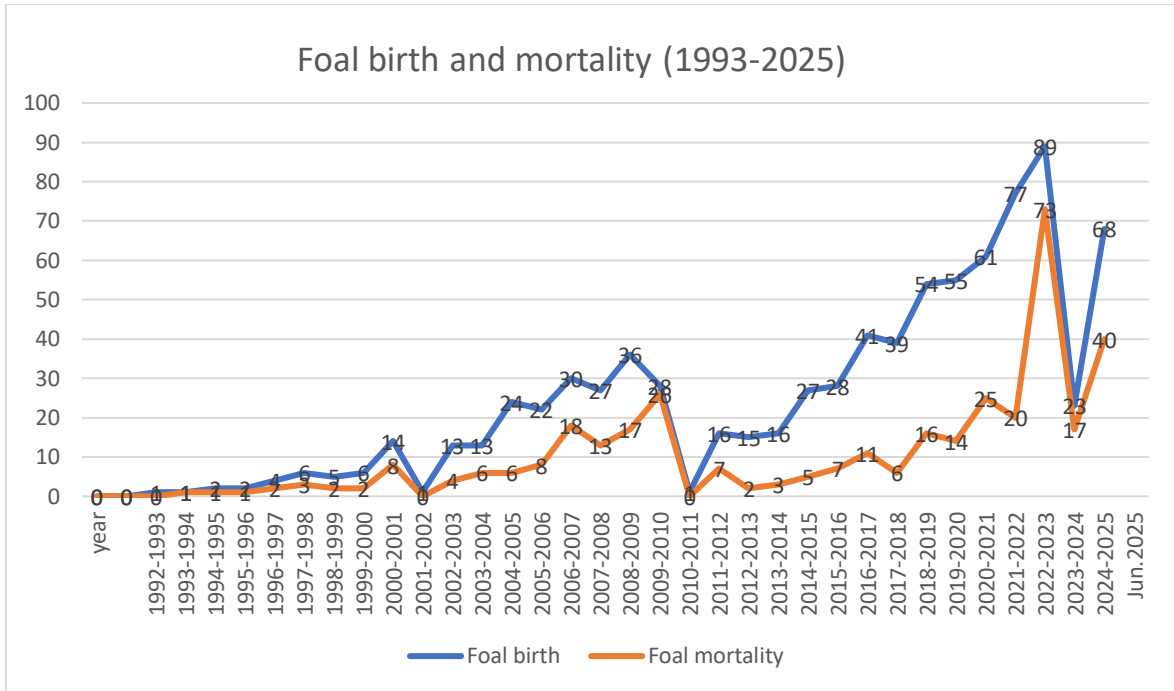


Figure 5. Foal birth and mortality trends of Takhi (1993–2025)



The lack of population growth is directly related to foal births and mortality. In 2022, **89 foals** were born and **73 died**; in 2023, **25 foals** were born and **17 died**; and in 2024, **68 foals** were born and **40 died**.

3.3 Factors Affecting the Takhi Population

To assess the impact of weather, the effect of dzud on the Takhi population was compared:

:

Figure 6. Comparison of Takhi (Przewalski’s horse) population and dzud index, 2022–2024

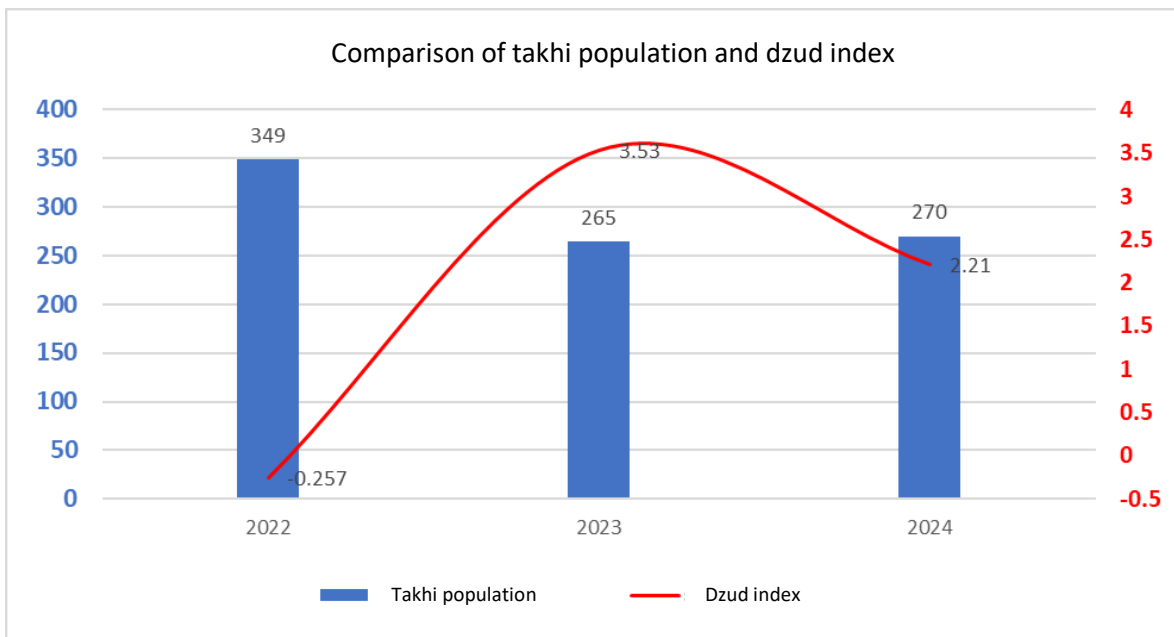


Table 1. Dzud severity index for 2022–2024

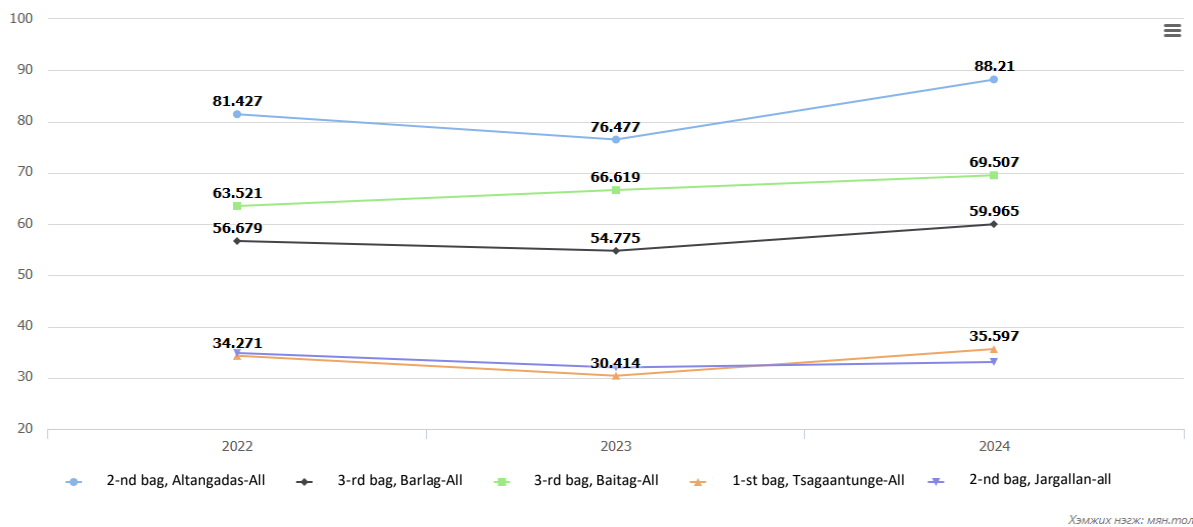
Year	$S_{\text{summer}}, S_{\text{зүх}}$	$S_{\text{winter}}, S_{\text{өбөл}}$	Dzud index	Number of takhi
2022	2.359451	0.57782	-0.257	349
2023	1.299843	-1.17434	3.53	265
2024	0	-0.91114	2.21	270

During the 2009–2010 dzud, a total of **8.5 million livestock**, or **20% of Mongolia’s total livestock**, perished (Report of the National Agency for Meteorology and Environmental Monitoring, 2012). The dzud index for that year was calculated at **4.9**, whereas the dzud index for 2022–2023 was **3.5**, indicating a relatively severe dzud compared to other years. The following year (2023–2024) showed a dzud-like winter with an index of **2.21**.

The livestock numbers (horses, cattle, sheep, goats, camels) for the last three years in the soums within the Gobi Strictly Protected Area were compared.

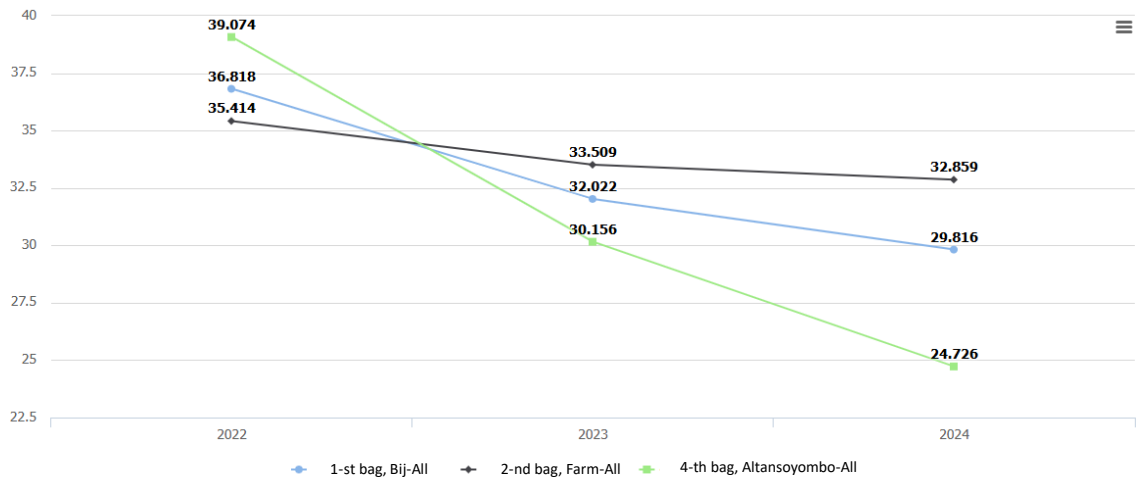
Altan Gadas and Barlag bags of Altai soum, Baytag bag of Bulgan soum, Tsagaantünge bag of Üench soum, and Jargalan bag: Livestock numbers for 2022–2024.

Figure 7. Livestock numbers in selected administrative bags, Govi-Altai aimag, 2022–2024 (source: www.1212.mn)



Livestock Numbers in Bij and Ferm Bags of Bugat Soum, and Altansoyombo Bag of Tonkhil Soum, Govi-Altai Aimag (2022–2024):

Figure 8. Livestock numbers in selected administrative bags, 2022–2024 (source: www.1212.mn)



ХЭМЖИЛХ ХЭЭЖИГ: МИРНУМОН

When examining the livestock numbers in these bags over the past three years, a common trend of decline during the dzud winter of 2023 is observed. However, in 2024, the livestock numbers in soums belonging to **Khovd aimag** increased, whereas those in soums belonging to **Govi-Altai aimag** decreased. This differing trend corresponds closely with the observed Takhi population growth and mortality around the core Takhi habitats: **Takhi Us oasis** (located in Altai soum, Khovd aimag) and **Khoni Us oasis** (located in Tonkhil soum, Govi-Altai aimag)..

Table 2. Mortality of Takhi (Przewalski's horse), 2022–2025

Year	Total mortality	Winter mortality	Adult Takhi Mortality		Foal mortality	
			Khoni us	Takhi us	Khoni us	Takhi us
2022-2023	173	162	75	25	58	4
2023-2024	18	6	1	0	5	0
2024-2025	67	49	27	0	22	0

3.4 Changes in Distribution Area and Comparison

All observed Takhi points (5,547 field observation points and 3,723 SMART program records) were combined to compare locations and distribution area (ha).

Table 3. Comparison of Takhi Distribution Area

Year	Field Observation Data (ha)	SMART Observation Data (ha)
2023	296,200	—
2024	380,200	353,964
2025	307,600	331,790

When calculating the area, 4 erroneous SMART program records were excluded. The difference in area between field observation data for 2024–2025 was **72,600 ha**, and the variation in SMART program data was **22,174 ha**.

Figure 9. Locations of all Takhi (Przewalski’s horse) observations, 2022–2025

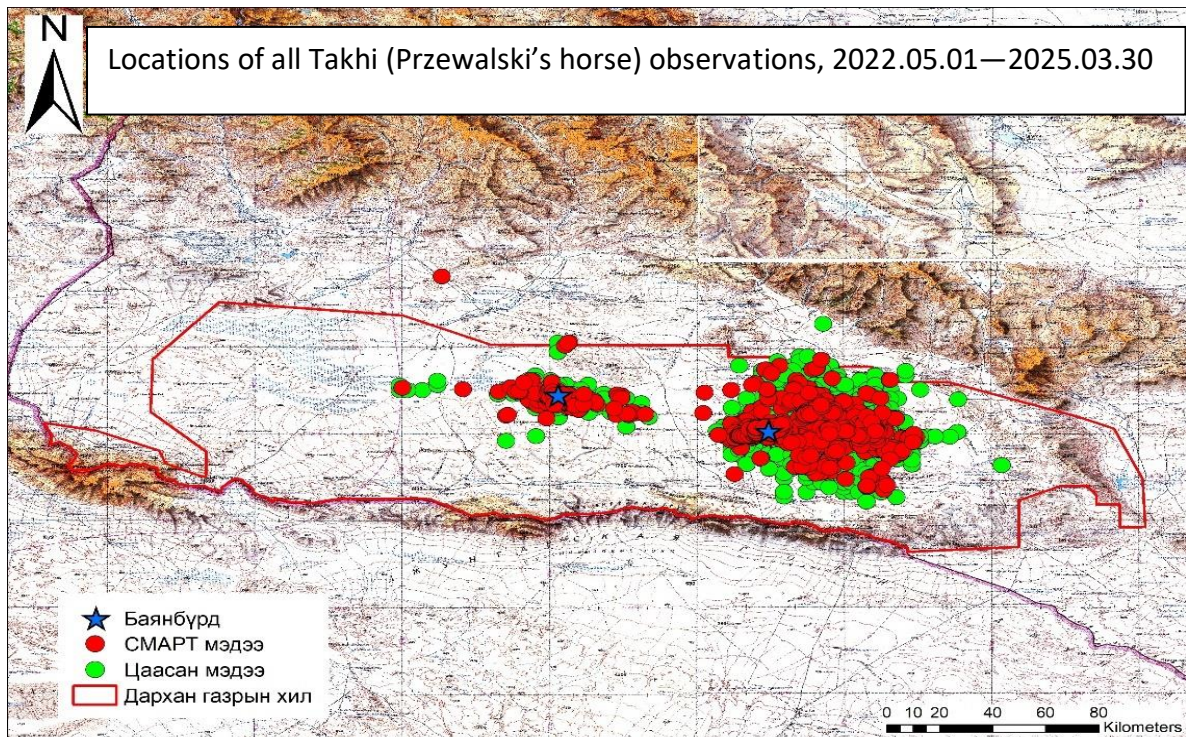


Figure 10. Locations of Takhi (Przewalski's horse) observations, 2022–2023

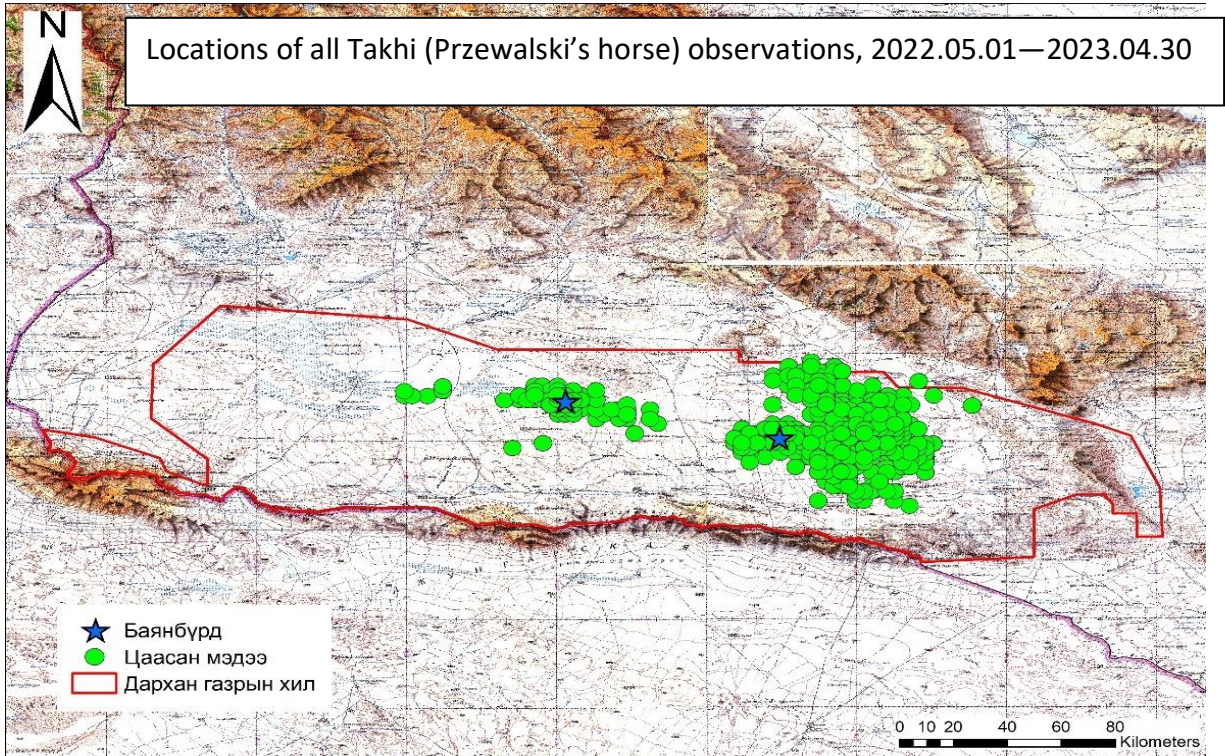


Figure 11. Locations of Takhi (Przewalski's horse) observations, 2023–2024

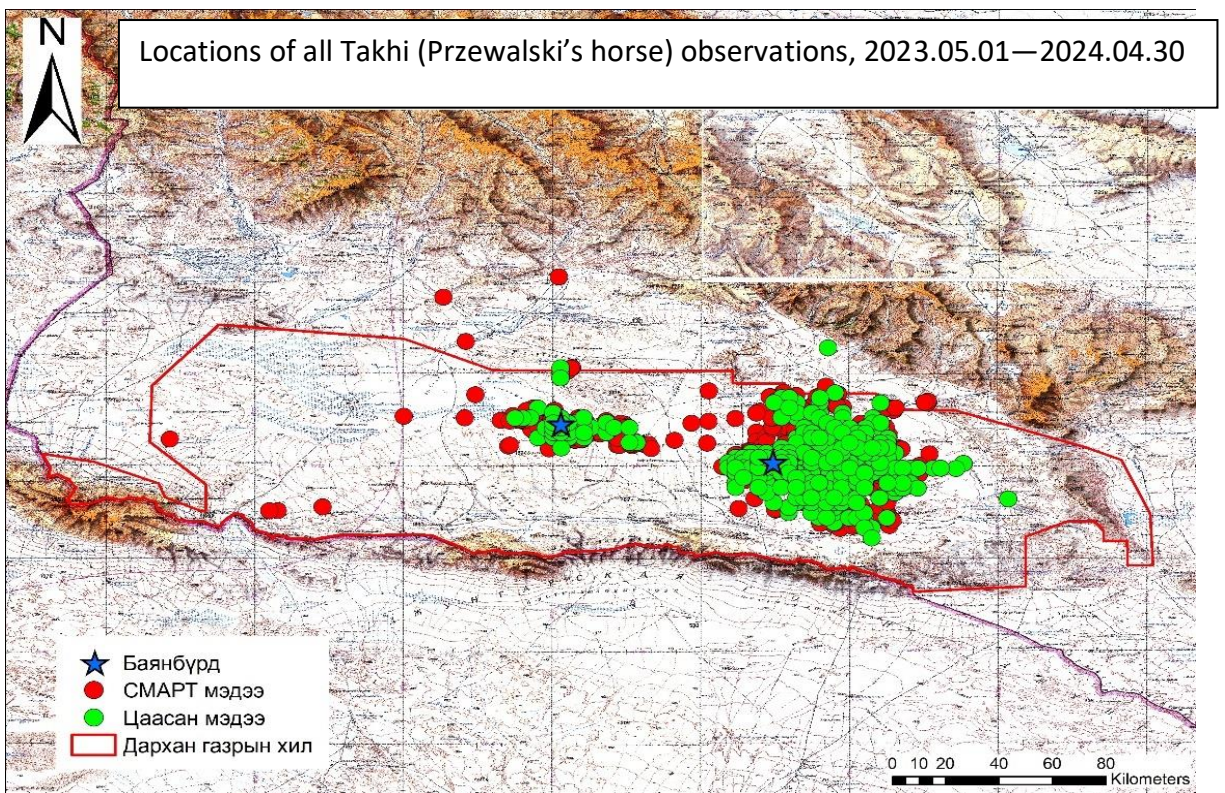


Figure 12. Locations of Takhi observations (2024–2025)

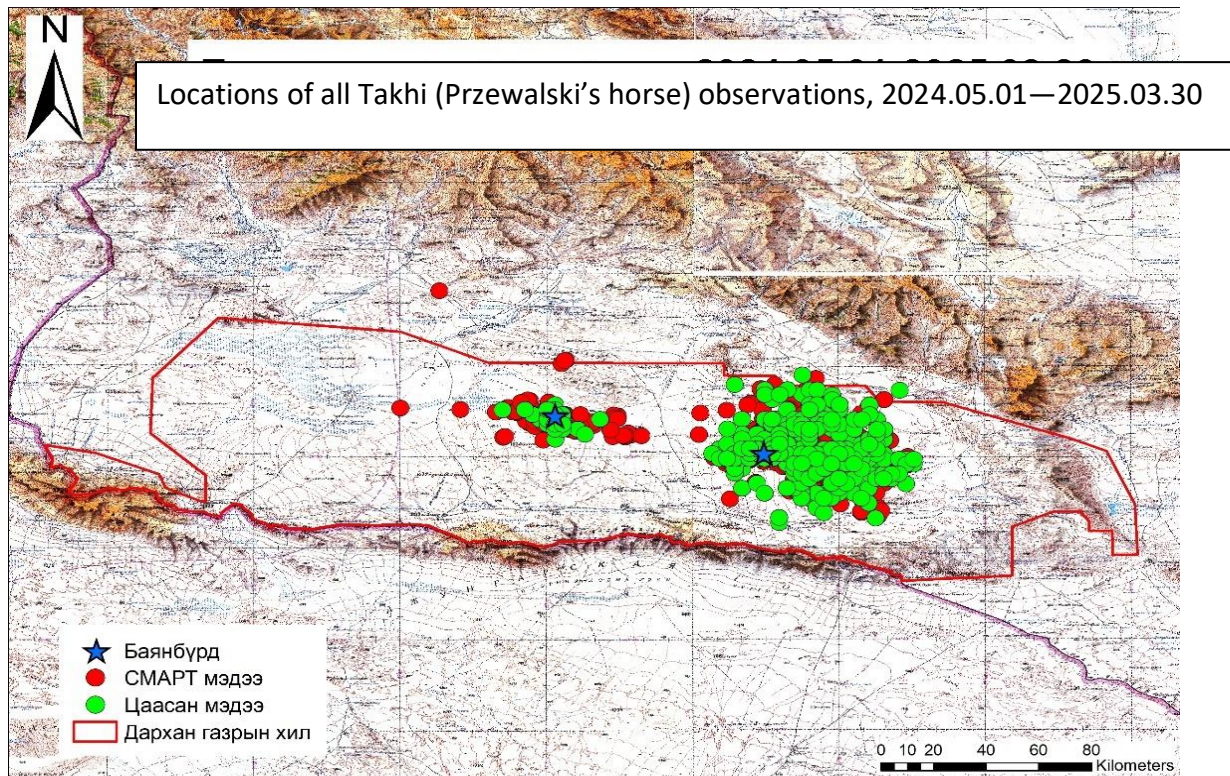
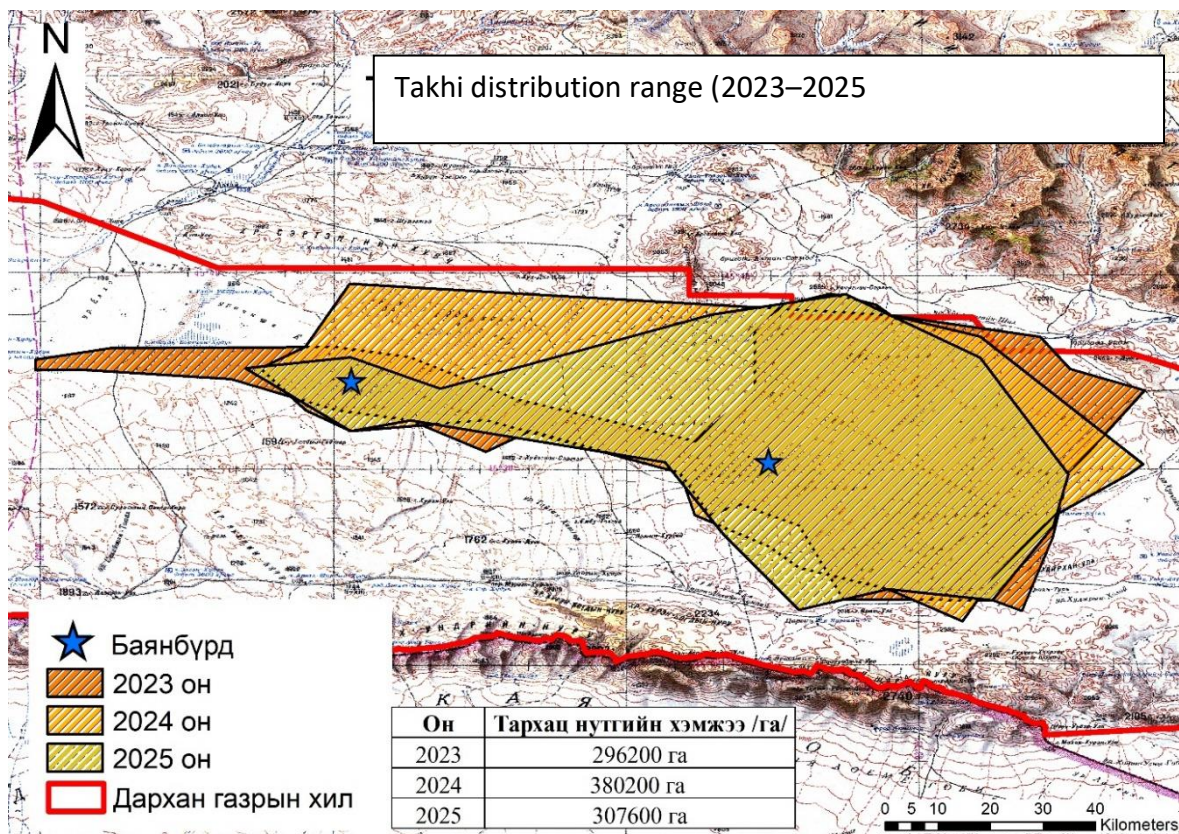


Figure 13. Changes in Takhi distribution range (2023–2025)



DISCUSSION

Evaluating the reintroduced Takhi in the Dzungarian Gobi at the population level was not only an opportunity to implement a new research methodology, but also a crucial step in determining the long-term conservation outcomes within the ecosystem. This study is distinctive in that it integrates traditional field observations with SMART program data, covering multiple indicators including population size, herd structure, changes in distribution area, reproduction, and mortality.

When implementing population monitoring, Takhi herds were recorded according to harem size, age, sex, behavior, and location. This approach was effective under field conditions where individual identification at the animal level is limited. However, because individual identification, conception rates, and reproductive success could not be measured quantitatively, some results were interpreted qualitatively, which carries a potential risk for the theoretical robustness of the study.

Population dynamics from 2022–2025 showed instability, with a sharp decline observed in 2023. This coincided with a high dzud index (3.53) that year, demonstrating that climatic factors strongly influence the life cycle of the Takhi population. This conclusion aligns with the climate–population relationship theory commonly used in studies of rare species (Sæther & Bakke, 2000) and highlights an important factor requiring further attention in Mongolia.

SMART program data were suitable for efficiently calculating the distribution area over time. Of the 3,723 data locations collected, only five were erroneous, indicating that the newly implemented program is reliable with a low likelihood of error.

In terms of behavior, newly formed herds after the severe winter of 2023 exhibited infanticide—killing of non-offspring foals—which negatively affected population growth. Furthermore, the role of dominant mares and the spatial behavior of stallions in herd structure and territory protection should be verified through long-term studies.

Comparing distribution areas, in line with the decline in population, the area decreased from 380,200 ha in 2023 to 331,790 ha in 2025, highlighting the need to study the influence of factors such as forage availability, water points, and livestock numbers.

In conclusion, this study is one of the few in Mongolia to implement Takhi monitoring at the population level using a dual-method approach based on modern information technology. To expand and improve monitoring, field observations could be enhanced using drones, thermal and motion-sensor automatic cameras, as well as genetic-level studies and integrated monitoring of vegetation and pasture ecology.

CONCLUSION

Implementing population-level monitoring of reintroduced Takhi in the Dzungarian Gobi represented a significant and effective step forward in this field of research. Evaluating Takhi population size, herd structure, and changes in distribution using a dual-method approach (traditional observations and SMART program) provided realistic and reproducible results. This approach also demonstrated that, in situations where individual identification is not possible, herd-level counts are an effective alternative.

Population growth over the past three years was unstable. Specifically, the population declined sharply in 2023, and growth slowed from 2024 onward. The study identified key contributing factors, including harsh climatic conditions (high dzud index), mortality of leading stallions in main herds, and the formation of new herds. Furthermore, newly formed herds exhibited strong infanticide behavior, leading to reduced reproduction and foal survival, highlighting the need for further behavioral studies.

The use of the SMART program proved advantageous for timely data collection and processing, allowing rapid analysis of numerical data and realistic assessment of distribution areas. However, potential human errors during data entry remain a limitation, indicating the continued need to combine SMART data with traditional paper-based records for validation.

Analysis also showed that the size of Takhi distribution areas corresponds with total population size: when the population decreased, the distribution area contracted. For example, the previously recorded area of approximately 450,000 ha decreased to 331,790 ha in 2025, reflecting the influence of forage availability, water resources, and pasture carrying capacity.

Comparisons of Takhi herds around the Takhi Us and Khoni Us oases, combined with local livestock data, showed that after the 2023 dzud, populations in Khovd aimag increased, while those in Govi-Altai aimag declined. This pattern reflects differences in environmental conditions, forage availability, and livestock pressure in these regions.

In conclusion, combining population-level monitoring with geospatial software in Takhi research provides a foundation not only for population assessment but also for understanding reproduction, behavior, and dynamics of distribution. Future improvements, such as drone-based counts and automated camera observations, will support the collection of more detailed and high-quality data.

RECOMMENDATIONS

1. As Takhi are becoming increasingly wild each year, it is necessary to use remote sensing methods to accurately calculate their distribution and locations.
2. Automatic cameras should be installed around core Takhi habitats, including oases and water points, to compare with other research data.
3. Some protected area staff should be trained and specialized in Takhi harem observation and research techniques.
4. A long-term research team should be maintained to study the outcomes of this multi-year, well-funded project.
5. The carrying capacity of pastures and the species composition of vegetation in core Takhi habitats and oases should be investigated.
6. In Khoni Us oasis, during the breeding season, large mixed herds (160–170 individuals observed in July 2024) should be separated and studied individually to understand harem dynamics, with drone surveys considered a suitable method.

Reference

- Bandi, N., Dorjraa, O., Ösökhjargal, D., Ganbaatar, O., & Enkhsaikhan, N. (2012). *Takhi in its native habitat*. Ulaanbaatar, Mongolia.
- Bannikov, A. G. (1954). *Mammals of the Mongolian People's Republic*. Moscow, Russia: USSR Academy of Sciences.
- Batsaikhan, N., Samyaa, R., Shar, S., Lkhagvasüren, D., & King, S. R. B. (2014). *Field guide to mammals of Mongolia*. Ulaanbaatar, Mongolia.
- Batsaikhan, N., Samyaa, R., Shar, S., Lkhagvasüren, D., & King, S. R. B. (2014). *Field guide to mammals of Mongolia* (2nd ed., pp. 20–293). Ulaanbaatar, Mongolia.
- Batchuluun, E. (2001). *Glossary of physical-geographical terms*. Ulaanbaatar, Mongolia: Mongolian State University of Education.
- Batchuluun, E. (Ed.). (2020). *Physical geography of Mongolia*. Ulaanbaatar, Mongolia: Mönkhny Üseg LLC.
- Batchuluun, E. (2022). *English–Mongolian and Mongolian–English geography dictionary*. Ulaanbaatar, Mongolia: Mongolian State University of Education; Mönkhny Üseg LLC.
- Gromov, I. M., & Baranova, G. I. (1981). *Catalogue of mammals of the USSR*. Moscow, Russia.
- Dash, D. (2015). *Landscape-ecological issues of Mongolia*. Ulaanbaatar, Mongolia: Admon Print LLC.
- Dovchin, N. (1969). A brief history and current status of Takhi (*Equus przewalskii* P.) in Mongolia. *Proceedings of the Institute of Biology*, 4, 52–67.
- Dulamtsüren, S. (1970). *Field guide to mammals of Mongolia*. Ulaanbaatar, Mongolia.
- Dulamtsüren, S. (1991). Did capturing Takhi foals affect wild herds? *Takhi Project, Proceedings of Scientific Workshop*. Ulaanbaatar, Mongolia.
- Klimov, V. V. (1990). *The Przewalski horse*. Moscow, Russia.
- Red Book of Mongolia. (1997). Ulaanbaatar, Mongolia.
- Mönkhүү, Z. (2012). *Summary of general geomorphology* (2nd ed.). Ulaanbaatar, Mongolia: Mönkhny Üseg LLC.
- Mönkhbat, B. (2024). Recent climate changes in Mongolia: Drought and dzud [Electronic resource].
- Ösökhjargal, D. (2021). Population dynamics and influencing factors of reintroduced Takhi (*Equus przewalskii* Poljakov, 1881) in Khustai National Park (Ph.D. dissertation). Ulaanbaatar, Mongolia.
- Sanjmyatav, Z. (2011). *Physical geography of Mongolia*. Ulaanbaatar, Mongolia: Mongolian State University of Education; ShME LLC.
- SMART Program Methodology. (2023). *SMART monitoring methodology*. Retrieved from <https://mecc.gov.mn/storage/library-items/September2023/kHSmz1sziJpJVewi8wCo.pdf>
- Polyakov, I. S. (1881). The Przewalski horse: A zoological sketch. *Proceedings of the Imperial Russian Geographical Society*, XVII(1), 1–19.
- Tsegmid, Sh. (1969). *Physical geography of Mongolia*. Ulaanbaatar, Mongolia: MAS, Institute of Geography and Geomorphology.
- Shagdar, Sh. (2000). *Concise dictionary of Mongolian geographical names*. Ulaanbaatar, Mongolia: Mönkhny Üseg LLC.
- Shagdarsüren, O. (1974). Modern status of game fauna and hunting economy in the Mongolian People's Republic and prospects [Doctoral dissertation]. Moscow, Russia.
- Mongolian Academy of Sciences, Institute of Geography. (2009). *National atlas of Mongolia* (2nd ed.). Ulaanbaatar, Mongolia.

- Mongolian Academy of Sciences, Institute of Geography and Geoecology. (2022). *National atlas of Mongolia* (3rd ed.). Ulaanbaatar, Mongolia.
- Enkhtör, A. (1998–2004). Biology and adaptation of reintroduced Takhi (*Equus przewalskii* Poljakov, 1881) in Khustai National Park [Research reports]. Khustai National Park, Mongolia.
- Enkhtör, A. (2009). Biology and ecological characteristics of reintroduced Takhi (*Equus przewalskii* Poljakov, 1881) in Mongolia (Ph.D. dissertation). Ulaanbaatar, Mongolia.
- Azzaroli, A. (1984). On some vertebrate remains of middle Pleistocene age from the Upper Valdarno and Val di Chiana, Tuscany. *Palaeontographia Italica*, 73(43), 104–115.
- Baasanmunkh, S., Urgamal, M., Oyuntsetseg, B., Sukhorukov, A. P., Tsegmed, Z., Son, D. C., Erst, A., Oyundelger, K., Kechaykin, A. A., Norris, J., Kosachev, P., Ma, J.-S., Chang, K. S., & Choi, H. J. (2022). Flora of Mongolia: Annotated checklist of native vascular plants. *PhytoKeys*, 192, 63–169. <https://doi.org/10.3897/phytokeys.192.79702>
- Baasanmunkh, S., Oyuntsetseg, B., Oyundari, C., Oyundelger, K., Urgamal, M., Darikhand, D., Soninkhishig, N., Nyambayar, D., Khaliunaa, K., & Tsegmed, Z., Kechaykin, A. A. (2021). The vascular plant diversity of Dzungarian Gobi in western Mongolia, with an annotated checklist. *Phytotaxa*, 501(1), 1–55.
- Benirschke, K., & Malouf, N. (1967). Chromosome studies of Equidae. In H. Dathe (Ed.), *Equus* (Vol. 1, No. 2, pp. 253–284). Berlin.
- Bennett, D. K., & Hoffman, R. S. (1999). *Equus caballus*. *Mammalian Species*, 628, 1–14.
- Bouman, J. G., & Bos, H. (1979). Two symptoms of inbreeding depression in Przewalski horses living in captivity. In L. E. M. de Boer, J. Bouman, & I. Bouman (Eds.), *Genetics and Hereditary Diseases of the Przewalski Horse* (pp. 111–117). Foundation for the Preservation and Protection of the Przewalski Horse, Rotterdam, The Netherlands.
- Bouman-Heinsdijk, I. (1982). Semi-reserves for Przewalski's horse. In J. Bouman, I. Bouman, & A. Groeneveld (Eds.), *Breeding Przewalski Horses in Captivity for Release into the Wild* (pp. 221–240). Foundation for the Preservation and Protection of the Przewalski Horse, The Netherlands.
- Forsten, A. (1988). Middle Pleistocene Replacement of Stenonid Horses by Caballoid Horses – Ecological Implications. *Paleogeography, Palaeoclimatology, Palaeoecology*, 65, 23–33.
- Gombobaatar, S. (2019). *Biodiversity of Mongolia: Names, distribution and identification of vertebrate species*. Mongolica Nature Guides. Ulaanbaatar, Mongolia. pp. 39–423.
- Gentry, A., Clutton-Brock, J., & Groves, C. P. (2004). The naming of wild animal species and their domestic derivatives. *Journal of Archaeological Science*, 31, 645–651.
- Geyer, C., & Thompson, E. (1988). Gene survival in the Asian wild horse (*Equus przewalskii*): I. Dependence of gene survival in the Calgary breeding group pedigree. *Zoo Biology*, 7, 313–327.
- Geyer, C., Thompson, E., & Ryder, O. (1989). Gene survival in the Asiatic wild horse (*Equus przewalskii*): II. Gene survival in the whole population, in subgroups, and through history. *Zoo Biology*, 8, 313–329.
- Groves, C. P. (1986). The taxonomy, distribution and adaptations of recent equids. In R. H. Meadow & H. P. Uepermann (Eds.), *Equids in the Ancient World* (pp. 11–65). Dr Ludwig Reichert Verlag, Wiesbaden, Germany.
- Grum-Grzhimailo, G. E. (1892). The wild horse (*Equus przewalskii*). From the diary of a travel to China in 1889–1890 (P. Aleinikov, Trans.). *Niva*, 17.

- SDC, ITG. (2021). *“Improvement of water management in the Great Gobi “B” strictly protected area (GGBSPA)” төслийн тайлан*. Улаанбаатар. 24 х.
- Nyambayar, D., Oyuntsetseg, B., Tungalag, R. (Comps.), Jamsran, Ts., Sanchir, Ch., Bachman, S., Soninkhishig, N., Gombobaatar, S., Baillie, J. E. M., & Tsendeekhuu, Ts. (Eds.). (2014). *Regional Red List Series Vol. 9. Plants (Part 1)*. Zoological Society of London, National University of Mongolia.
- Mohr, E. (1971). *The Asiatic Wild Horse*. J. A. Allen and Co. Ltd. London. 124 pp.
- Oyuntsetseg, B., Baasanmunkh, S., Nyambayar, D., Batkhuu, N., Lee, C. H., Sun, C. K., Chung, G. Y., & Choi, H. J. (2018). *The conservation status of 100 rare plants in Mongolia*. Korea National Arboretum, Pocheon. 232 pp.
- Oakenfull, E. A., Lim, H. N., & Ryder, O. A. (2000). A survey of equid mitochondrial DNA: Implications for the evolution, genetic diversity and conservation of *Equus*. *Conservation Genetics*, 1, 341–355.
- Ryder, O. (1994). Genetic studies of Przewalski’s horses and their impact on conservation. In L. Boyd & D. A. Houpt (Eds.), *Przewalski’s horse: The history and biology of an endangered species* (pp. 75–92). State University of New York Press, Albany.
- Ulziikhutag, N. (2019). *Survey of the flora of Mongolia*. Ulaanbaatar, pp. 102–106.
- Urgamal, M., Oyuntsetseg, B., Tungalag, R., Gundegmaa, V., Oyundari, C., Tserendulam, C., Munkh-Erdene, T., & Solongo. (2019). *Red List of Mongolia 2*. Ulaanbaatar. 230 pp. [in Mongolian]
- Zimmermann, W. (1999). Feasibility study, site selection and development of a reintroduction project of the Przewalski’s horse (*Equus ferus przewalskii*) in the Dzungarian Gobi in Mongolia. In B. Gerken & C. Meyer (Eds.), *Proc. Int. Symp. Neuhaus/Solling, 21–23.4.1998: Natural and man-made landscape – History, models and perspectives for the development of European landscapes with large herbivores*.