Odessa centre | Pastoralism
Research, Policy and Practice

TYPE Original Research
PUBLISHED 25 March 2025
DOI 10.3389/past.2025.14289

Check for updates

OPEN ACCESS

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RECEIVED 02 January 2025
ACCEPTED 11 March 2025
PUBLISHED 25 March 2025

CITATION
Bolormaa T, Burenjargal S, Sandagdorj B, Chantsal B, Ochirkhuu N, Gerelt-Od S and Nyam-Osor P (2025) The role and significance of two-humped camels in Mongolia: adaptability, economic impact, and cultural importance. *Pastoralism* 15:14289. doi: 10.3389/past.2025.14289

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The role and significance of two-humped camels in Mongolia: adaptability, economic impact, and cultural importance

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This study examines the multifaceted role of the two-humped camel (*Camelus bactrianus*) in the livelihoods of Mongolian pastoralists, focusing on its adaptability to extreme climates, economic contributions, and cultural significance. Camels are essential for the production of meat, milk, and wool, which account for 54% of total cash income in certain regions. They also provide essential draft power for transportation, tourism, and sports. The study reveals variations in camel distribution across Mongolia's natural zones and highlights their resilience in supporting herders under diverse ecological conditions. The reproductive and lactation cycles of camels, adapted to Mongolia's distinct climate, further highlight their suitability for pastoral systems. This research emphasizes the importance of promoting sustainable camel farming practices through supportive policies and investments to improve pastoral livelihoods and to ensure the preservation of Mongolia's camel-rearing heritage.

KEYWORDS

bactrian camel, pastoral livelihoods, economic significance, adaptability, camel milk

Introduction

Bactrian or two-humped camels (*Camelus bactrianus*) are primarily distributed across China, Mongolia, Kazakhstan, Russia, Iran, Afghanistan, and Pakistan (Vyas et al., 2015; Zarrin et al., 2020). Camels have significant economic value due to their ability to adapt to extreme climates (Yagil, 1985). A growing interest in camel milk and meat has highlighted the importance of both Dromedary and Bactrian camels, attracting attention from herders and scientists for their role in sustainable livestock production (Burger et al., 2019; Faraz et al., 2021). In Mongolia, five species of livestock, namely cattle, camels, goats, horses, and sheep are traditionally raised for milk (Ganzorig et al., 2020), meat, and other purposes (Tserenpuntsag, 1970). Of these, camels have shown the greatest resilience to harsh natural conditions (Nyamsuren, 2016). They have provided food for Mongolian nomadic

herders in extreme climatic conditions for centuries, symbolizing strength and endurance and forming an integral part of farming culture (FAO, 2024). Animal husbandry contributes significantly to Mongolia's economy, accounting for 10.9% of the gross domestic product, 5.6% of export earnings, and employing 25.5% of the workforce. The sector covers 71.2% of the country's total area, with more than 80% of the local economy depending on it (NSO, 2021). As of 2023, Mongolia's livestock population totals 64.7 million, comprising 7.5% horses, 8.3% cattle, 45.5% sheep, 38.1% goats, and 0.7% camels. Despite their small share in the livestock population, camels are included in the "Breeding Strategy Five Species of Livestock Animals" of the Ministry of Food, Agriculture, and Light Industry of Mongolia for 2020–2030, which aims to increase their numbers (MOFALI, 2020). Three recognized breeds contribute to the Mongolian camel-based herding community. The Hos Zogdort breed is particularly valued for its high wool productivity, averaging 6.6–8.0 kg per camel annually. The other two breeds, Galbiin Gobiin Ulaan, are more valued for meat, while Haniin Hetsiin Huren camels are less valued for milk. Regardless of these traits, all three breeds equally serve a variety of roles within the community (Chuluunbat et al., 2014). Camels have traditionally provided meat, milk, wool, and hides (Nurtazi et al., 2017). Recently, camel farming has expanded globally, with a focus on increasing milk and wool production. While Mongolia has a long history of camel rearing, modern semi-intensive camel farms are set to begin operations in Umnugobi and Bayankhongor provinces in 2024. Camel milk has been found to contain bioactive components beneficial for disease prevention and treatment, with potential effects on cancer, diabetes, bacterial and viral infections, blood pressure regulation, immune support (Seifu, 2022), autism, tuberculosis, liver function, and food allergies (Khan et al., 2016). Camel meat, which is lower in cholesterol and higher in protein compared to beef, supports immunity, muscle and bone strength, and skin hydration, while the fat extracted from the camel's hump is used for pain relief (Khan et al., 2016). Two-humped camels yield higher-quality wool than their one-humped counterparts (Dong, 1979). Approximately 70% of camel wool is fine, with the wool from young and female camels being particularly soft, akin to goat cashmere. This wool is utilized to produce blankets, mattresses, ropes, clothing, tents, carpets, coats, saddles, and other items (Yam and Morteza, 2015). In line with the Mongolian government's policy support, the FAO has provided technical assistance to strengthen the camel milk value chain, establishing the first semi-intensive camel milk farm in Umnugovi province, where one-third of the camel population is concentrated. Furthermore, the United Nations General Assembly has declared 2024 as the Year of the Camel (FAO, 2024). This initiative, supported by Mongolia and other two-humped camel countries, aims to establish the World Two-Humped Camel Association. Thus, this study was conducted to determine the distribution of grazing camels in Mongolia's natural regions and to elucidate the role and importance of these animals in the livelihoods of pastoral herders.

Materials and methods

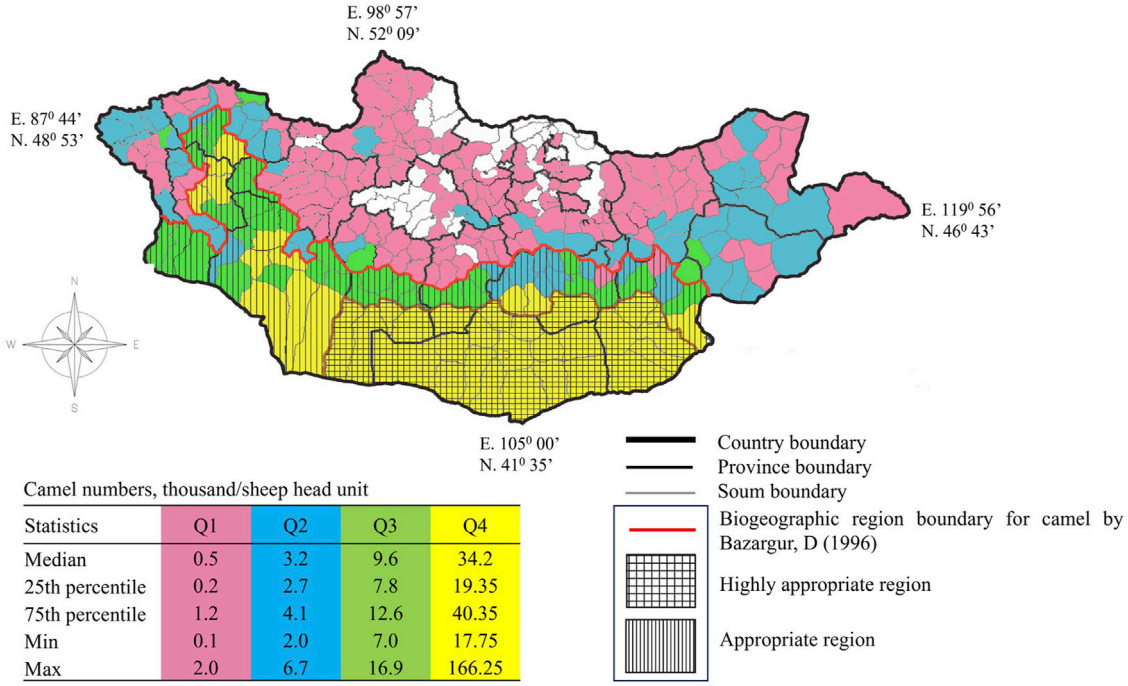
Camel distribution

Mongolia is administratively divided into 339 soums (administrative units) in 21 provinces and the capital city of Ulaanbaatar (NSO, 2023). The country spans diverse natural zones, situated between the frigid taiga of Siberia and the arid deserts of Central Asia, creating a highly variable and extreme climate (Bazargur, 1996; Yembuu, 2021). Average annual temperatures range from +15°C to +22°C in the summer, with extreme highs of +28°C to +44°C, and from −20°C to −25°C in the winter, with absolute lows ranging from −31.1°C to −55.3°C (Yembuu, 2021). The number of camels within the soums of Mongolia was estimated using data from the 2023 livestock census, as provided by the National Statistics Office database. In compliance with Article 6.2 of the Land Payment Law of Mongolia, camel populations in each soum were converted to sheep head units using a coefficient of 5.0. This standardized unit enabled the calculation of camel numbers by equating one camel to five sheep. The converted camel numbers were then categorized into quartiles based on the 25th, 50th, and 75th percentiles in descending order. For each quartile, camel distribution zoning was created on the map of Mongolia according to the corresponding soums. The proportion of camels within the livestock structure for each Zone was compared to other livestock species. The coefficients for this comparison were 7.0 for horses, 6.0 for cows, and 0.9 for goats.

Statistical analysis

Statistical zoning methods were used to analyze the distribution of two-humped camels in Mongolia, aligning with administrative boundaries at the soum level. The analysis followed local livestock counting census, was integrated with the government data system, and enabled comparisons with other livestock species. Questionnaire data were processed using Microsoft Excel, and additional statistical analyses were conducted with the trial version of JMP (JMP, Cary, NC, United States). One-way ANOVA, based on median values, was performed to assess differences pastoral herders cash income from camels across different zones, followed by Wilcoxon's nonparametric *post-hoc* tests for pairwise comparisons.

In response to these climatic and ecological variations, Bazargur (1996) classified Mongolia into three biogeographic



Camel numbers, thousand/sheep head unit

Statistics	Q1	Q2	Q3	Q4
Median	0.5	3.2	9.6	34.2
25th percentile	0.2	2.7	7.8	19.35
75th percentile	1.2	4.1	12.6	40.35
Min	0.1	2.0	7.0	17.75
Max	2.0	6.7	16.9	166.25

FIGURE 1
Distribution of two-humped camels in Mongolia.

regions for each livestock type: highly appropriate, appropriate, and less appropriate. This classification considers factors such as topography, climate, pasture, soil characteristics, and livestock distribution and density. According to the 2023 statistical data, camels were recorded in 291 of the soums, while 48 soums reported no camels. The distribution of camels in these regions is depicted on a map, with camel numbers converted to sheep-equivalent units and assigned to four zones. The zones are represented by different colors: Zone 1 in red, Zone 2 in blue, Zone 3 in green, and Zone 4 in yellow (Figure 1). Descriptive statistics of camel numbers per soum within each zone are included in the map.

The 48 soums without camels fall into areas deemed less appropriate for camel rearing. These areas include the elevated regions of the Khuvsgul Mountains, which mark the southernmost edge of the vast taiga forests of Eastern Siberia, along with parts of the Khangai Mountain Range and the Orkhon-Selenge river basins. The mountainous soums are characterized by rocky peaks, cliffs, glaciers, permafrost, and remnants of ancient glaciation. These high-altitude Zones experience a cold and harsh climate with strong winds and sparse vegetation. The lower regions feature unique vegetation patterns that include meadows, thickets, and moss-lichen-covered terrain (Orkhonselenge, 2015).

Bazargur et al. (2009) delineated three Zones based on the bioecological characteristics of camels: highly appropriate, appropriate, and less appropriate zones. Notably, the entirety of Zone 1 falls into the less appropriate category for camel settlement. In Zone 2, 22.6% of the area is considered appropriate for camels, while 77.4% is less appropriate for camel rearing. Conversely, 87% of Zone 3 is classified as appropriate, while 13% is deemed less appropriate. Zone 4 consists entirely of soums categorized as highly appropriate or appropriate for camels.

Across these zones, 150 soums from 20 provinces fall into Zone 1, with a median of 0.5 camels per soum, accounting for 3.95% of all camels. Zone 2 includes 62 soums from 17 provinces, with a median of 3.2 camels per soum, accounting for 8.74% of the total camel population. Zone 3 consists of 38 soums from 10 provinces, with a median of 9.6 camels per soum, representing 16.96% of the camel population. Zone 4 encompasses 41 soums from 8 provinces, with a median of 34.2 camels per soum, accounting for 70.35% of the total camel population. Notably, camel numbers are significantly higher in Khanbogd (166.3), Mandal-Ovoo (114.1), Manlai (83) soums in Umnugobi Province, Bayanlig soum in Bayankhongor Province (86), and Ulziit soum in Dundgobi Province (84.15).

Despite the varying suitability of these areas for camels, Mongolian pastoral herders have reared and relied on camels for their livelihoods in all regions. This highlights the adaptability and importance of camels in Mongolian pastoral culture. The socio-economic role of camels was further assessed through

TABLE 1 Ratio of camels to other livestock species in each zone.

Zone	Camel/Cattle	Camel/Horse	Camel/Sheep	Camel/Goat
Zone 1	1:203	1:212	1:217	1:110
Zone 2	1:26	1:32	1:37	1:26
Zone 3	1:3.9	1:1.5	1:1.2	1:1.4
Zone 4	1:0.5	1:1.7	1:1.6	1:3.2

TABLE 2 Age and sex structure of the camel herd by zone.

Zone	Bull camel		Cow camel		Castrated male camel		Subadult		Yearling	
	Median	Range	Median	Range	Median	Range	Median	Range	Median	Range
Zone 1	1	0–1	11	1–42	7	1–77	5	0–18	5	0–20
Zone 2	1	0–2	18	3–70	8	0–32	9	1–33	7	1–30
Zone 3	1	0–3	15	2–107	10	0–95	6	0–45	7	0–51
Zone 4	2	1–6	47	15–520	19	4–198	21	8–215	21	6–233

questionnaires distributed to herdsmen in each zone. Table 1 presents the ratio of camels to other livestock species in the herd structure, highlighting their contribution to herders' livelihoods.

Table 1 shows that the ratio of camels in the herd structure is very low in Zone 1, at 1:110–217. This ratio increases significantly in Zone 2 to 1:26–37. In Zone 3, it further increases to 1:1.2–3.9, and in Zone 4, it reaches 1:0.5–3.2, where camels dominate the livestock structure. The primary benefits of camels are their meat and milk. As ruminant animals, camels can be compared to cattle in some respects. Observing the ratio of cattle to camels within the herd structure, it is evident that the importance of camels increases from 1:203 in Zone 1 to 1:0.5 in Zone 4.

The results of the camel herd composition by age and sex reveal that the herds consist of 38%–43% cow camels, 17.3%–25.6% castrated male camels, 33.3%–38.2% juvenile or calf camels, and 1.8%–3.4% bull camels. The detailed herd composition figures in each zone were: 23.5% cow camels, 9.5% castrated male camels, 10.5% juvenile camels, and 10.5% calf camels per bull camel (Table 2). These figures were 7.5, 5, 3, and 3.5 in Zone 3; 9.5, 4, 3.5, and 4.5 in Zone 2; and 5.5, 3.5, 2.5, and 2.5 in Zone 1. This indicates that the number of other camels per bull camel in Zone 4 is almost double that in other zones. According to Bediye et al. (2018), camels are managed at a ratio of at least 1:5-7, averaging 1:10–30, and a maximum of 1:20–50, which closely matches the ratios observed in the zones. However, detailed studies of herd composition by camel age and sex are limited. In the Afar region of Ethiopia, studies have shown that camel herds consist of 56.6% lactating camels, 30.9% dry camels, and 12.4% male camels (Gebremichael et al., 2019). In the Kereyu region of Ethiopia, 90% of camel herds are female, with 30% being lactating camels. In Kenya, 70% of camels are lactating, indicating that households primarily raise camels for milk production, with male camels often culled for meat at a young age (Elhadi et al., 2015).

Camels play a multifaceted role in the livelihoods of pastoralists, providing meat, milk, and wool (Faraz et al., 2021). Table 3 details the economic benefits of camels, illustrating their contribution to the total income of pastoral households in cash terms.

Based on the questionnaire results, meat, milk, and wool constitute the primary sources of cash income for herders. The table shows the income contributions of meat, milk, and wool across the four zones. The results indicate significant variation in income contributions from meat, milk, and wool across the four zones (p-values: meat = 0.0035, milk = 0.0017, wool = 0.0001). Zone 1 has the lowest total income (6.9%), with a minimal contribution from milk (0.3%). Zone 2 has a medium income level (12.7%), with wool (7.0%) contributing slightly more than meat (5.3%). Zone 3 generates a relatively high income from milk (11.8%) but moderate levels from meat (6.9%) and wool (7.7%). In contrast, Zone 4 is the most productive, yielding the highest total income (54.0%), with milk (21.0%) and meat (18.0%) as the dominant contributors. The relationship between herd size and income generation differs across products. Wool income shows a strong correlation with herd size across all zones ($R^2 > 0.90$), suggesting that wool production remains stable regardless of regional characteristics. In contrast, milk income has a weak association with herd size, as shown by the low R^2 values in Zones

TABLE 3 Income contribution of key camel products by zone.

Zone	Percentage contribution to total income				Herd size and its association with income sources					
	Meat	Milk	Wool	Total income contribution (%)	Camel herd size (percentiles)			Meat	Milk	Wool
	p = 0.0035	p = 0.0017	p = 0.0001		50th	25th	75th	R2 for the sources		
Zone1	2.7[d]	0.3[c]	3.9[c]	6.9	30	18	53	0.005	0.129	0.95
Zone2	5.3[c]	0.4[b]	7[bc]	12.7	43	19	88	0.56	0.13	0.93
Zone3	6.9[b]	11.8[a]	7.7[b]	26.4	40	30	79	0.8	0.45	0.97
Zone4	18[a]	21[a]	15.3[a]	54	113	92	148	0.94	0.54	0.98

Superscripts indicate statistical significance.

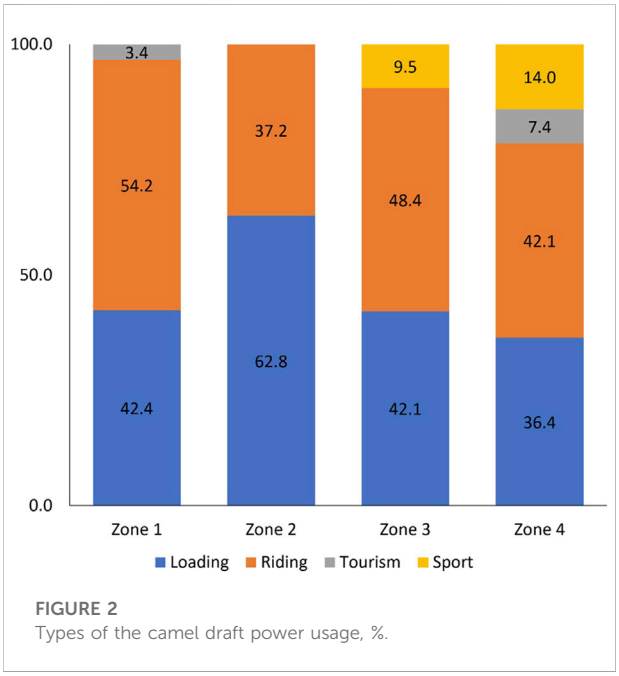


FIGURE 2
Types of the camel draft power usage, %.

1 and 2 (0.129 and 0.13, respectively). This suggests that factors other than herd size, such as draft power and regional camel utilization practices, significantly influence milk production. Meat income shows varying levels of dependence on herd size across the zones. In Zone 1, the low R^2 (0.05) indicates that meat income is largely independent of herd size, possibly due to low slaughter rates, cultural preferences, or limited market access. In contrast, Zone 4 shows a strong dependence (R^2 = 0.94), where meat income increases proportionally with herd size, likely due to higher slaughter rates and greater market demand. Total income increases with herd size, but the contribution of each product varies by region. Zone 1, with the smallest herd size, has the lowest total income (6.9%), whereas Zone 4, with the largest herd size, has the highest total income (54%). In addition to their cash value, the draft power provided by camels is crucial to the livelihoods of herder families. The questionnaire identified four primary uses of camel draft power such as loading, riding, tourism, and sports, as shown in Figure 2.

Archaeological evidence from Central Asia dating to the early 2nd millennium BC suggests that domesticated two-humped camels were used primarily for load carrying (Sala, 2017). These camels have historically been integral draft animals in arid and semi-arid regions, such as those in India, where they are employed in agriculture and transportation (Castell et al., 2004). In Mongolia, two-humped camels have historically been used in military campaigns (Sala, 2017) and continue to be used for long-distance transportation, load-carrying, and riding. Despite advances in communication and transportation, camels remain essential in areas that lack modern transportation infrastructure, such as river and mountain regions. Figure 3 illustrates the current use of camel power by herders. In Zone 1, 96.6% of the camel draft power is used for load carrying, with tourism accounting for 3.4% due to its recent development. In Zone 2, camels are used exclusively for load carrying, while in Zone 3, 90.5% is for load carrying and 9.5% for sports. In Zone 4, 78.5% is for load carrying, 7.4% for sports, and 14% for tourism. Comparative studies in other camel-using countries, particularly in Africa (Bengoumi and Faye, 2015) and Arab (Bediye et al., 2018) nations, indicate similar uses for transportation, agriculture, racing, tourism, and the production of meat, milk, wool, and leather, with transportation being the predominant use.

Mongolian nomads continue to rely heavily on camels as an integral part of their traditional lifestyle, particularly as transport animals for seasonal migrations. Camels are primarily used as load carriers, tasked with transporting dismantled Gers (traditional tent houses) and their key possessions during relocations. This role is especially vital during the otor (seasonal migrations in search of better pastures), which ensures pasture-based fattening of livestock in warmer seasons and livestock survival in harsh climatic conditions in colder seasons. The UNESCO Intangible Cultural Heritage List listed

FIGURE 3
Usage of the camel with regional characteristics. **(A)** Herder migration to summer camp in the mountainous western part of Mongolia, Baatar canyon, Zereg soum, Khovd province. **(B)** Herder migration to autumn camp in the plateaued eastern part of Mongolia, Tsantiin khooloi, Bayanhutag soum, Khentii province. **(C)** Camel milking in autumn (calf camel at this age called *botgo*), Khuld soum, Dundgobi province. **(D)** Camel milking in spring (calf camel at this age called *torom* born in previous year/spring) Khuld soum, Dundgobi province. **(E)** Camel riding for herding camels in spring (she-camels with newly born calves), Tsogt soum, Gobi-Altai province. **(F)** Camel riding for herding various types of livestock in winter, Sumber soum, Gobisumber province.

the pastoral nomads of Mongolia's way of life as "Mongolian Nomadic Ritual Practices" in December 2024 (UNESCO, 2024). The use of camels varies regionally, as shown in Figure 3. In the mountainous western regions (Figure 3A), camels play a crucial role in transporting household goods during migration, where the rugged terrain makes them the most reliable means of transportation. In contrast, in the plateaued eastern regions (Figure 3B), camels are also used for migration, demonstrating their adaptability to different landscapes. The importance of camel milk production is also evident across regions. In the semi-arid central regions (Figures 3C, D), camels are milked during autumn and spring, supporting local dairy

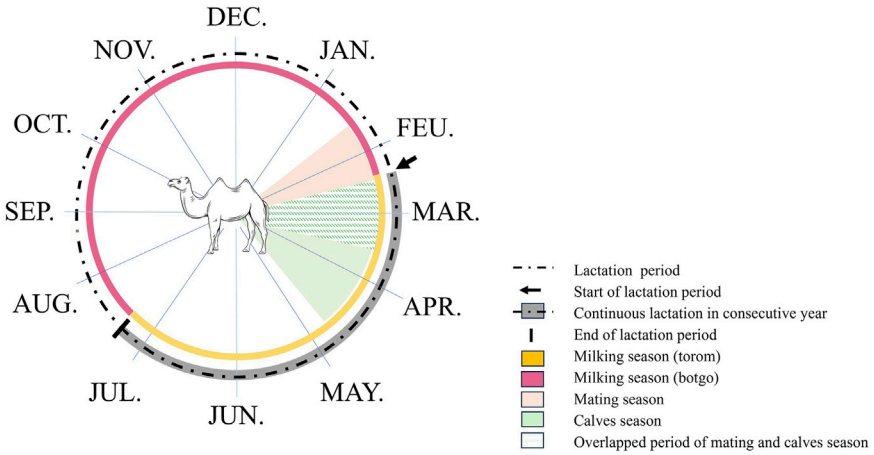


FIGURE 4
Reproductive and lactation cycles of cow camel.

production and providing sustenance for herding families. Furthermore, in the Gobi Desert and steppe areas, camels are indispensable for herding livestock. In spring (Figure 3E), herders rely on camels to manage camel herds with newborn calves, while in winter (Figure 3F), camels serve as transport for mixed livestock herding, showcasing their resilience under varying conditions.

In addition to transportation, camels provide essential resources for the daily nourishment of herders. Camel milk is a dietary essential, often boiled with water to prepare milk tea, a central element of Mongolian cuisine. Additionally, camel milk is fermented to produce *hoormog*, a nutrient-dense beverage renowned for its energy-restoring properties, attributed to its high vitamin content. Camels also play a critical role in herding other livestock, especially during the harsh winter and spring when their resilience and strength are indispensable. This multifaceted reliance on camels demonstrates their enduring importance in maintaining the traditional practices of Mongolian nomads and helping them adapt to the challenges of Mongolia's extreme environment. Figure 4 summarizes responses to a questionnaire on the reproductive and lactation cycles of Mongolian two-humped camels under pasture grazing conditions.

Mongolia experiences four distinct seasons characterized by significant temperature fluctuations, low rainfall, and marked variations in latitude and altitude (Sumiya et al., 2022). These seasons are categorized as follows: late winter (January-March), spring (April-May), summer (June-August), autumn (September-October), and early winter (November-December) (Rosenbaum et al., 2019). This climatic diversity plays a critical role in the reproductive patterns and lactation management of camels in Mongolia.

Camels calve once every 2 years, with an average lactation period of 17.6 months followed by a dry period of approximately 6.4 months (Buyankhishig, 2011). The timing of mating is influenced by climatic conditions, geographical location, and nutritional status, with the optimal mating period under grazing conditions occurring during the cold season (Tseweenjav, 1990; Lamo et al., 2023). According to herders, male camels typically reach breeding age at 3-4 years, while females are bred at 4-5 years. Bull camels are usually replaced every 3-4 years to minimize the risk of inbreeding. Mating in Mongolia generally occurs from late January to mid-March, coinciding with the transition from winter to spring. Camels have a gestation period of 13-14 months, with calving typically occurring between mid-March and late April. The lactation period lasts approximately 16–18 months, consistent with the findings of Keskes et al. (2013) and Gansaikhan et al. (2014). For one-humped camels, the gestation period averages 12-13 months, while for two-humped camels, it ranges from 12 to 14 months (Lamo et al., 2023).

The milking season varies from region to region due to environmental conditions, the number of cow camels in herding households, and traditional milk usage practices. In Zones 1 and 2, milking occurs from late August to early January (approximately 2–5 months). In Zone 3, the period extends from July to February (5–8 months), while in Zone 4, milking is practiced all year round (July to July). Newly calved cow camels are not extensively milked for the first 7 months until their calves are mature enough to graze, except for small trials to help calves adapt to being tied and become familiar with humans. Cow camels with a previous calf are milked until their milk dries up, with a dry period of 6 months before the next calving.

The results of this study align with previous findings regarding the sexual maturity and breeding patterns of camels. Male camels typically reach sexual maturity at 4-5 years of age, and females at 6-7 years of age (Khanvilkar and Ambore, 2009). For one-humped camels, the optimal breeding age is 3-4 years of age for females and,

4-5 years of age for males (Bediye et al., 2018). These findings are consistent with the herders' observations reported in this study.

Globally, the timing of camel mating varies slightly based on regional climatic conditions. Skidmore (2019) reported that mating occurs from December to March in Pakistan, from December to April in Egypt, from November to March in the majority of Arab countries, and from mid-January to mid-April in China. The questionnaire results from this study closely align with these patterns, emphasizing the influence of regional climate and husbandry practices on camel reproduction and lactation. For both one-humped and two-humped camels, the mating period occurs predominantly during the colder seasons in their respective regions of distribution.

Results and discussion

Questionnaire and data collection

In 2024, 204 questionnaires were collected from 53 randomly selected soums in different zones. Data were gathered by interviewing household heads from 19 soums in Zone 1, 10 soums in Zone 2, 6 soums in Zone 3, and 18 soums in Zone 4. The questionnaires contained 27 questions grouped into four categories: camel usage, productivity, reproduction, and lactation cycles.

Conclusion

This study highlights the pivotal role of the two-humped camel in Mongolian pastoralism, presenting their remarkable adaptability to diverse geoecological zones. Camels are integral to the livelihoods of herders, providing vital resources such as meat, milk, wool, and draft power. Camels are economically indispensable, particularly in regions where they thrive, contributing significantly to household income. The study highlights the need for continued research and investment to maximize the benefits of camel farming and ensure the resilience and sustainability of Mongolia's pastoral economy.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical approval was not required for the studies involving animals in accordance with the local legislation and institutional requirements because animal rights and welfare are not violated in this study. Written informed consent was obtained from the owners for the participation of their animals in this study. Each pastoral herder participating in the questionnaire has agreed to advance data collection and authorize the researchers to use the results and photographs.

Author contributions

Methodology: TB; questionnaire: TB, SB, BC, NO, SG-O, and BS; formal analysis: TB and PN-O; supervision: PN-O; writing–original draft: TB and PN-O; writing–review and editing: TB and PN-O. All authors reviewed the results and approved the final version of the manuscript.

Funding

The author(s) declare that financial support was received for the research and/or publication of this article. This research was funded by the Mongolian Fund for Science and Technology, grant number ShuSs 2024/13.

Acknowledgments

We would like to express our sincere gratitude to all the herders who participated in the questionnaire, for their warmth, cooperation, and active involvement in this research. This work was partially supported by the "Project to Strengthen the Practical Capacity of Public and Private Veterinarians" funded by the Japan International Cooperation Agency and implemented at the School of Veterinary Medicine, Mongolian University of Life Sciences (2020–2025), for the collection of questionnaire data. We also sincerely thank Emily Chun, a Mandarin teacher at MULS from Min Chuan University, Taiwan, and Timothy Blanton, a dedicated volunteer and native English speaker, for their invaluable time and effort in proofreading this work, which significantly improved its clarity and readability.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that no Generative AI was used in the creation of this manuscript.

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