



Reproductive Management of Female Dromedary and Bactrian Camels: Features of Hormonal Regulation and Ovarian Activity during the Mating Season

Yernur Sakhariyev ¹, Kanat Koibagarov ², Shinara Kassymbekova ², Valery Terletskiy ³, Damir Khussainov ², Asset Turgumbekov ², Serik Khizat ², Assem Kalykova ⁴ and Yessengali Ussenbekov ^{2*}

¹Shakarim University, Semey 071410, Republic of Kazakhstan

²Kazakh National Agrarian Research University, Almaty 050010, Republic of Kazakhstan

³Pushkin Leningrad State University, St. Petersburg-Pushkin 196605, Russia

⁴Al-Farabi Kazakh National University, Almaty 050040, Republic of Kazakhstan

*Corresponding author: yessengali.ussembekov@kaznaru.edu.kz

Article History: 25-217

Received: 07-Aug-25

Revised: 25-Sep-25

Accepted: 07-Nov-25

Online First: 20-Nov-25

ABSTRACT

Reproductive physiology in camels has unique features compared to other domestic animals, particularly regarding hormonal regulation and ovarian activity during the mating season. Understanding the dynamics of sex hormones and their receptors is important for improving reproductive management and developing effective breeding programs. The objective of the study was to identify the features of hormonal regulation and ovarian activity during the mating period in order to improve the efficiency of reproductive management in female Dromedary and Bactrian camels. To achieve this, we examined the dynamics of progesterone and estradiol receptors, as well as the concentration of progesterone in the blood serum of non-pregnant female camels of Dromedary (n=10) and Bactrian (n=10) breeds during the mating season. The camels were divided into three groups according to their geographical region. Blood serum samples were analyzed using enzyme-linked immunosorbent assay (ELISA), and ultrasound scanning of the ovaries was performed on three Dromedary camels for 30 consecutive days to monitor follicular development. The results showed an abrupt increase in the concentration of progesterone and estradiol receptors in 35–40% of the animals studied. In contrast, Bactrian camels demonstrated relatively stable serum progesterone levels throughout the experiment, ranging from 3.71 to 5.76ng/mL. No correlation was found between progesterone, estradiol, and their receptor levels, likely due to the random assignment of animals to experimental groups. Ultrasound monitoring revealed that the growth of multiple subdominant follicles accompanied the development of a dominant follicle in Dromedary camels. In conclusion, the findings indicate that camels do not exhibit a distinct estrous cycle. However, the development of dominant and subdominant follicles occurs during the mating season, and ovulation is induced by copulation.

Keywords: Progesterone, Estradiol, Enzyme-linked immunosorbent assay, Estrous cycle, Ultrasound scan.

INTRODUCTION

Natural limitations of camels' reproductive function include a long period of reaching puberty, a limited breeding season, difficulties with induced ovulation, a long gestation period, and intervals between calving (Waqas et al. 2025). Efforts to improve the reproductive performance of camels are closely related to a better understanding of folliculogenesis, or the pattern of the follicular wave. Practical knowledge of ovarian function or the estrous cycle will be of great importance for applying assisted

reproductive technologies and improving reproduction in camels (Dauda et al. 2019; Zarrin et al. 2020; Niasari-Naslaji and Nikjou 2023). The regulation of folliculogenesis in camels is strongly influenced by endocrine factors. Follicle-stimulating hormone (FSH), luteinizing hormone (LH), and insulin-like growth factor 1 (IGF1) have been identified as key drivers of dominant follicle growth, while subdominant follicles typically undergo atresia (Alharbi 2022; Alhaider 2023). The dominant follicle passes through active growth, a static phase, and eventually regression (Price and Estienne 2018).

Cite This Article as: Sakhariyev Y, Koibagarov K, Kassymbekova S, Terletskiy V, Khussainov D, Turgumbekov A, Khizat S, Kalykova A and Ussenbekov Y, 2025. Reproductive management of female dromedary and bactrian camels: features of hormonal regulation and ovarian activity during the mating season. *International Journal of Veterinary Science* 14(6): 1152-1161. <https://doi.org/10.47278/journal.ijvs/2025.142>

Previous studies have shown that the duration of the follicular wave cycle in Arabian camels ranged from 25 to 30 days, and the duration of estrus from 5 to 7 days. Progesterone levels were low (<3.2 nmol/L) throughout the cycle, while estradiol levels were high during estrus; the corpus luteum was absent during the natural cycle, suggesting that Arab camels ovulate reflexively (Alfurajji 1999; Abdulkareem et al. 2015).

Marked fluctuations in LH, estrogen, and progesterone have been reported depending on the stage of the cycle, with estradiol peaking during estrus while progesterone remains consistently low in the absence of pregnancy (Moussa et al. 2019; Mohamed et al. 2021). The estrous cycle is the period that lasts from one estrus to the next one (Pineda 2003). In other words, it is a combination of physiological events that begins in one estrus and ends in the next one. The estrous cycle in animals that ovulate spontaneously, such as sheep, goats, and cows, is usually divided into two broad phases: the follicular and luteal phases (Lopera-Vásquez et al. 2022). Unlike these species, the estrous cycle in induced animals such as camels is characterized by repetitive waves of follicle growth and regression. Due to reflex-induced ovulation, they do not have a classical estrous cycle. Seasonality and the presence or absence of mating also play an important role. Estradiol concentrations decrease after the follicle reaches ovulatory size if mating does not occur, and ovulation is not induced (Basiouni 2007; Skidmore 2011; Fedorova et al. 2015; Asadi et al. 2025). The estrous cycle or follicular wave model in such animals consists of recruitment, follicle growth, maturity, and regression phases. Peripheral concentrations of estradiol increase with increasing follicle diameter until the follicle reaches 1.7cm in diameter, after which concentrations begin to decrease, even if the follicle itself continues to grow (Mohamed et al. 2023).

Progesterone and estradiol are considered important biomarkers of pregnancy in camels and can serve as useful tools for early detection and reproductive management (Faraz et al. 2022). However, despite accumulating evidence, detailed data on the dynamics of these hormones and their receptors in camels from different ecological regions remain limited. Therefore, the purpose of the study was to identify the features of hormonal regulation and ovarian activity during the mating period in order to

improve the efficiency of reproductive management in female Dromedary and Bactrian camels.

MATERIALS AND METHODS

Research design

To achieve the research objective, the dynamics of progesterone, estradiol, and progesterone hormone receptors in the blood plasma of randomly selected female Dromedary camels during the mating season were investigated across three different geographical zones of the Republic of Kazakhstan, along with the growth characteristics of dominant and subdominant follicles assessed by ultrasound scanning.

Location

The study was conducted in 2025 in several regions of Kazakhstan, specifically in the Otyrar district of the Turkestan region (group A, 42.85°N, 68.30°E.), the Isatai district of the Atyrau region (group B, 47.67°N, 50.67°E), and the Almaty region (group C, 45.00°N, 78.00°E) (Fig. 1).

These locations were deliberately selected to represent distinct ecological and climatic zones of Kazakhstan – arid desert-steppe in the south (Turkestan), semi-arid continental climate in the west (Atyrau), and temperate mountainous conditions in the southeast (Almaty). This geographic diversity allowed for the assessment of regional variation in hormonal dynamics and follicular development, providing a more comprehensive understanding of camel reproductive physiology across natural habitats.

Sampling and research stages

For the enzyme-linked immunosorbent assay (ELISA), blood serum samples were obtained from randomly selected non-pregnant female camels during the mating season, without determining their adaptation to extreme climatic conditions, physical or functional characteristics, or stage of the estrous cycle (Table 1). The females were divided into three groups according to their geographical habitat zones. In group C, ultrasound examinations of the ovaries were conducted over a 26-day period at intervals of 2 to 4 days to study the growth dynamics of dominant and subdominant follicle.



Fig. 1: Location of study area.

Table 1: Description of camel groups selected for blood serum sampling

Group	Camels breed (n)	Age range (years)	Sampling interval and period
A	Dromedary camels (n=9)	5-13	Samples were collected every 48 hours during the mating season from 9 to 19 January 2025
B	Bactrian camels (n=5) and Dromedary camels (n=1)	5-14	Samples collected every 48 hours from 15 to 31 January 2025
C	Dromedary camels (n=3)	5-7	Ultrasound monitoring of ovarian follicular dynamics was conducted for 26 days at 2–4-day intervals

In private farms, serum samples were separated, and aliquots of 200µL of each sample were prepared, with each sample consisting of five pieces. The serum samples were stored at a temperature of -18°C. After that, the necessary studies of the prepared serum were carried out.

Methods and equipment

Blood from camels was collected from the jugular vein and, in some cases, from the caudal vein into vacuum tubes, in amounts of 3-4mL. Ultrasound scanning was performed using PU 2200 and Mindray Z5 Vet devices with an endocrine sensor that can scan the examined organ in various modes: B/2B/4B/M/B+M. All blood tests were conducted in the Department of Clinical Disciplines laboratory of the Kazakh National Agrarian Research University.

The blood serum levels of the progesterone receptor in group A and the estradiol receptor in groups A, B, and C were determined using an ELx808 enzyme immunoassay analyzer (microplate reader), a washer, and a thermoshaker using commercial kits including Camel Progesterone Receptor (PGR) ELISA Kit Cambridge, UK (Catalog No. MBS067495) and Camel Estradiol Receptor (E2R) ELISA Kit (Catalog No. MBS093483) by MyBioSource.com according to the manufacturer's instructions. The sensitivity of the Camel Estradiol Receptor (E2R) ELISA Kit (Catalog No. MBS093483) was 0.1ng/mL, with a detection range of 0.25ng/mL to 8ng/mL. The content of progesterone hormone in blood serum samples from camels in groups B and C was determined using the Camel Progesterone ELISA Kit from Antibodies.com, according to the manufacturer's instructions.

Data analysis

Based on the absorption measurement results, a standard linear curve was constructed, and the data were then converted to digital absorption values using Microsoft Excel, along with data on the concentration of the progesterone receptor and estradiol. We used R-Studio software (version 4.3.1) to visualize the results of determining the concentration of progesterone and estradiol receptors, as well as the hormone progesterone, which allowed for identifying the peak points of the progesterone and estradiol receptors, as well as the hormone progesterone.

In addition, descriptive statistics (mean±SD) were calculated for each experimental group. The normality of data distribution was assessed using the Shapiro–Wilk test. Because the data were not normally distributed ($P<0.05$), differences between Groups A, B, and C were analyzed using the non-parametric Kruskal–Wallis test, which serves as an analogue to one-way ANOVA for non-normal data. Statistical significance was accepted at $P<0.05$.

RESULTS

In experimental group A of 9 camels, 5 specimens had a maximum increase in progesterone receptor concentration during the experimental period (samples 1, 2, 7, 8, 9), animal number 1 had 2.84ng/mL on the second day of the study, and animal number 2 had 2.16ng/mL on the first day of the study, camel number 7 had 2.63ng/mL on the 8th day of the study, camel number 8 had 2.62ng/mL on the 6th day of the study, and camel number 9 had 2.55ng/mL on the 2nd day of the study. In the remaining female camels, the progesterone receptor concentration fluctuated slightly for 12 days and ranged from 0.60ng/mL to 2.01ng/mL (Table 1).

In experimental group A, according to the results of the estradiol receptor content analysis in 9 camels, six animals showed an increase in estradiol receptor concentration. Samples No. 1 and 2 on the 12th day of the study showed 3.24ng/mL and 6.62ng/mL; samples No. 3 and 4 on the 10th day of the study showed 2.54ng/mL and 3.12ng/mL, sample No. 5 on the 8th day of the study showed 4.08ng/mL, and sample No. 7 on the 2nd day of the study showed 3.81ng/mL. The remaining animals did not show an increase in the concentration of the estradiol receptor during the experiment, and the level of the estradiol receptor was at the basal level (Table 1).

In experimental group B of 5 Bactrian camels and 1 Dromedary camel, one Bactrian camel on the 8th day of the study and one Dromedary camel on the 10th day of the study showed an increase in the level of the hormone estradiol receptor, equaling 2.22ng/mL and 2.70ng/mL, respectively. During the study period, the estradiol receptor level in camel No. 2 ranged from 0.75ng/mL to 1.30ng/mL for 16 days, in camel No. 3 from 0.44ng/mL to 1.41ng/mL, in camel No. 4 from 0.73ng/mL to 1.35ng/mL, and in camel No. 6 from 0.77ng/mL to 1.4ng/mL (Table 2).

In experimental group B, the dynamics of hormone progesterone levels for 16 days in camels fluctuated slightly in all studied Bactrian and Dromedary camels. All specimens showed one small peak in the concentration of progesterone hormone, in camel No. 1 on the 5th day of the study (4.53ng/mL), in camel No. 2 on the 1st day of the study (5.20ng/mL), in camel No. 3 on the 8th day of the study (5.06ng/mL), in camel No. 4 on the 13th day of the study (4.78ng/mL), in camel No. 5 on the 9th day of the study (5.76ng/mL), and in camel No. 6 on the 9th day of the study (5.16ng/mL) (Table 3).

In experimental group C, camel No. 1 in the experimental period on the 4th and 6th days of the study showed a maximum increase in the concentration of the hormone progesterone, reaching 6.44ng/mL and 6.06ng/mL, followed by a decrease in progesterone concentration (Table 5). In camel No. 1 under study, during the experimental period, the concentration of the estradiol receptor remained at the basal level, with fluctuations ranging from 0.44ng/mL to 1.30ng/mL (Table 4).

Table 1: ELISA results of the analysis of progesterone and estradiol receptor concentrations in randomly selected Dromedary camels during the mating season in South Kazakhstan (n=9)

Item No.	Camel, name	Age	Date of blood collection 09.01.25		Date of blood collection 11.01.25		Date of blood collection 13.01.25		Date of blood collection 15.01.25		Date of blood collection 17.01.25		Date of blood collection 19.01.25	
			Prog ng/mL	Estra ng/mL										
1	Sigan	13 years	2.25	1.67	2.84	0.95	1.22	1.58	0.95	1.71	1.47	0.96	1.34	3.24
2	Qaragöz	10 years	2.16	1.16	0.70	0.45	1.04	0.56	1.54	1.71	1.15	1.06	1.34	6.62
3	Qızılmaya	13 years	0.70	0.40	0.99	0.50	0.60	0.69	0.70	2.19	1.37	2.54	-	-
4	Shardara	15 years	2.01	0.54	1.04	0.44	1.47	0.61	1.52	0.62	1.24	3.12	-	-
5	Türkistan	9 years	0.87	0.61	0.73	0.49	1.32	0.60	1.89	4.08	1.56	1.13	1.94	1.78
6	Kişi Şar	5 years	0.85	0.51	0.84	0.62	1.21	0.61	1.26	0.62	1.54	0.75	1.05	0.66
7	Pışanay	5 years	0.60	0.54	0.72	3.81	1.79	0.78	1.17	1.12	2.63	1.08	1.73	0.88
8	Awqat	5 years	2.05	1.45	1.52	0.69	2.62	1.03	2.15	0.96	1.14	1.64	2.58	1.10
9	Qaratorğa	7 years	1.31	1.11	2.55	0.94	-	-	1.00	1.42	1.24	1.34	-	-

Table 2: ELISA results of estradiol receptor concentration analysis in randomly selected Bactrian camels (n=5) and Dromedary camels (n=1) during the mating season in West Kazakhstan

Item No.	Reference No., Name	Breed	Age, years	Date	Date								
				ng/mL 15.01	ng/mL 17.01	ng/mL 19.01	ng/mL 21.01	ng/mL 23.01	ng/mL 25.01	ng/mL 27.01	ng/mL 29.01	ng/mL 31.01	
1	01261435, Lenta	Bactrian	14	0.64	1.23	1.05	2.22	0.92	1.42	0.45	0.43	0.80	0.80
2	01261436, Sarı	Bactrian	14	0.75	0.92	1.05	1.02	0.96	1.21	0.97	0.81	1.30	1.30
3	01330414, Tostağan	Bactrian	12	0.91	0.76	1.28	1.05	1.41	1.37	0.76	0.46	0.44	0.44
4	01261437, Orınşa	Bactrian	14	0.73	0.99	0.90	1.05	0.87	1.35	0.95	0.92	0.80	0.80
5	no number, Aru ana	Dromedary	12	0.91	1.28	0.76	1.28	2.70	0.51	0.91	0.81	0.56	0.56
6	01330364, Martha	Bactrian	5	0.87	1.02	0.99	0.90	1.26	0.89	1.40	0.77	1.00	1.00

Table 3: ELISA results of the analysis of progesterone hormone concentration in randomly selected Bactrian (n=5) and Dromedary (n=1) camels during the mating season in West Kazakhstan

Item No.	Reference No., name	Breed, age	Date	Date	Date								
			15.01	17.01	19.01	21.01	23.01	25.01	27.01	29.01	31.01		
1	01261435 Lenta	Bactrian, 14 years	4.08	4.39	4.53	3.98	4.51	4.35	4.35	4.19	3.86	3.86	3.86
2	01261436 Sarı ingen	Bactrian, 14 years	4.71	5.20	4.69	4.97	4.24	4.49	4.35	4.19	4.03	4.03	4.03
3	01330414 Tostağan	Bactrian, 12 years	4.25	4.09	4.57	5.06	4.16	4.09	4.23	4.28	4.14	4.14	4.14
4	01261437 Orınşa	Bactrian, 14 years	4.18	3.97	4.73	4.43	4.64	3.94	4.78	4.31	4.02	4.02	4.02
5	no number, Aru ana	Dromedary, 12 years	4.80	4.78	4.53	4.97	5.76	4.86	4.77	4.89	4.61	4.61	4.61
6	01330364 Martha	Bactrian, 5 years	5.08	4.94	4.48	4.67	5.16	5.03	4.27	3.71	4.31	4.31	4.31

Table 4: ELISA results of the analysis of the concentration of progesterone hormone and estradiol receptor in randomly selected Dromedary camels (n=3) during the mating season in the Almaty region

Item No.	Camel age/hormone	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date
		1 28.01.25	2 30.01.25	3 1.02.25	4 3.02.25	5 5.02.25	6 7.02.25	7 9.02.25	8 12.02.25	9 14.02.25	10 16.02.25	11 18.02.25	12 20.02.25	13 22.02.25
1	10 years, progesterone	5.18	5.57	6.44	6.06	4.18	3.71	3.88	3.94	3.88	3.71	3.88	3.88	4.16
2	7 years, progesterone	4.86	4.47	4.61	5.09	5.18	5.57	6.02	5.72	4.86	4.47	4.61	5.09	4.58
3	5 years, progesterone	4.74	4.36	4.51	4.78	6.09	5.02	5.24	4.87	4.42	4.23	4.84	4.56	4.37
1	10 years, estradiol receptor	1.30	0.46	0.71	0.44	0.82	0.72	0.72	0.82	1.29	0.48	0.71	0.49	0.77
2	7 years, estradiol receptor	0.71	0.77	0.86	0.72	0.86	1.27	0.83	0.67	0.75	0.81	1.57	0.45	0.78
3	5 years, estradiol receptor	0.47	0.93	0.75	0.77	1.32	0.46	0.73	0.54	1.32	0.46	0.73	0.54	0.54

Table 5: The number of dominant and subdominant follicles detected by ultrasound scanning and follicles with signs of atresia during the experimental period in non-pregnant Dromedary camels (n=3) during the mating season in the Almaty region

The multiplicity of the study	Ultrasound examination period	Number of follicles	
		The right ovary	The left ovary
Camel No. 1 8	30.01.2025-22.02.2025	4SF+3 SF-2 SF-2 SF	2DF+1DF+1DF 2SF+3SF-3 SF 2 DFA (1.03.2025)
Camel No. 2 7	30.01.2025-22.02.2025	1DF+1SF+3SF+2SF	2SF+1SF+2SF
Camel No. 3 7	30.01.2025-22.02.2025	1 DF+2SF+2SF+3 SF 1 DFA (5.03.2025)	2SF+1SF

Note: DF is a dominant follicle, SF is a subdominant follicle, and DFA is a dominant follicle with signs of atresia.

At the same time, an ultrasound scan of the ovaries of selected camels was performed. On January 30, on the 2nd day of the study, two sufficiently large follicles with dimensions 1.86x2.25cm and 1.91x2.34cm were found in

the left ovary. The progesterone concentration was 5.57ng/mL on that day, and the estradiol receptor concentration was 0.46ng/mL. At the time of the ultrasound scan on February 3, 2025, this camel had two

dominant follicles with a diameter of 2.07x2.47cm and 2.25x2.89cm (Fig. 2A), as well as two subdominant follicles in the right ovary with diameters of 0.67x0.91cm and 0.54x1.13cm (Fig. 2B). The progesterone concentration was 5.57ng/mL on that day, and the estradiol receptor concentration was 0.46ng/mL. At the time of the ultrasound scan on February 3, 2025, this camel had two dominant follicles with a diameter of 2.07x2.47cm, 2.25x2.89cm (Fig. 2A) and two subdominant follicles in the right ovary with diameters of 0.67x0.91cm, 0.54x1.13cm (Fig. 2B). The concentration of the hormone progesterone was high and amounted to 6.06ng/mL. However, the camel's right ovary was in an inactive state, and two small subdominant follicles were

found on the sonogram (Fig. 2B). At the time of the ultrasound scan of the ovaries of camel No. 1 on February 7, 2025, one dominant follicle with a diameter of 2.31x2.42cm was found in the left ovary (Fig. 3A), at the next ultrasound scan of the left ovary of camel, this dominant follicle reached a maximum diameter of 3.09x3.21cm (Fig. 3B, dated 9.02.2025). A chronological ultrasound examination of the left ovary of camel No. 1 indicates that an ultrasound scan on February 22, 2025, revealed signs of atresia of one dominant and a nearby localized subdominant follicle (Fig. 4B). However, subdominant follicles with diameters of 1.60x1.94cm, 0.85-1.17cm were growing in the right ovary of camel No. 1 (Fig. 4A dated 19.02.2025).



Fig. 2: A) Sonogram of the left ovary of camel No. 1 showed two follicles with a size of 2.07x2.47cm and 2.25x2.89cm (3.02.2025). B) Sonogram of the right ovary of camel No. 1 showed two follicles with a size of 0.67x0.91cm and 0.54x1.13cm (3.02.2025).



Fig. 3: A) Sonogram of the left ovary of camel No. 1 showed one dominant follicle with a size of 2.31x2.42cm (7.02.2025). B) Sonogram of the left ovary of camel No. 1 showed one follicle with a size of 3.09x3.11cm (19.02.2025).



Fig. 4: A) Sonogram of the right ovary of camel No. 1 showed two subdominant follicles with a size of 1.60x1.94cm and 0.85-1.17cm (19.02.2025). B) Sonogram of the left ovary of camel No. 1 showed two follicles with signs of atresia (22.02.2025).

Sonogram analysis shows that in camel No. 2, an ultrasound scan of the right ovary on 1.02.2025 revealed one follicle. Subsequent ultrasound studies revealed small subdominant follicles present simultaneously with the dominant follicle in the right ovary. A total of 7 ultrasound scans showed one dominant follicle, six subdominant follicles in the right ovary, and five subdominant follicles in the left ovary in camel No. 2 (Fig. 5A, Table 5). In camel No. 3, ultrasound scanning of the left ovary revealed two subdominant follicles with diameters of 1.86x2.25cm and 1.19x1.08cm (1.03.2025). During the next ultrasound examination (5.03.2025), camel No. 3 had one dominant follicle with a diameter of 1.89x2.29cm in the right ovary, and on 5.03.2025, two subdominant follicles with a sufficiently large diameter of 1.88x1.86cm and 1.83x1.86cm in the left ovary. Ultrasound scans of the ovaries of three non-pregnant Dromedary camels were performed from January 30 to March 5, 2025, at various intervals. During an ultrasound scan of camel No. 1, only 11 subdominant follicles of different sizes were found in the right ovary during an 8-fold examination. One dominant follicle grew in the left ovary, starting from 1.86x2.25cm and reaching its maximum diameter on February 19, 2025 (3.09x3.21cm). An ultrasound examination on February 22, 2025, revealed signs of atresia of the dominant follicle. The results of the ultrasound show

that the left ovary was active in camel No. 1, and the right ovary was active in camel's No. 2 and No. 3, where the growth of dominant follicles was detected (Fig. 6, Table 5).

Thus, in the studied Dromedary camels (n=9) (group A), according to the results of an ELISA study during the mating season in South Kazakhstan, the concentration of the progesterone receptor ranged from 0.60ng/mL to 2.84ng/mL, and only four camels showed peaks of high concentrations of the progesterone receptor (2.16ng/mL, 2.84ng/mL, 2.62ng/mL, and 2.63ng/mL). The female camels were randomly selected for the experimental group, without determining their physiological status. Of the nine female camels tested, 4 showed peaks of high progesterone receptor concentration, which was 44.44%. During the ELISA study period, only three animals showed an increase in the concentration of the estradiol receptor in group A camels (camel No. 7 on the 2nd day of the study with 3.81ng/mL, camel No. 5 on the 6th day of the study with 4.80ng/mL, and camel No. 2 on the 10th day of the study 6.62 with ng/mL. In the remaining seven camels, the concentration of the estradiol receptor remained at the basal level, from 0.40ng/mL to 3.24ng/mL. Estradiol receptor and progesterone hormone concentrations were determined in experimental group B (n=6). In this group, peak concentrations of the estradiol receptor were found only in two camels (No. 1 on day 6 of the study with 2.22ng/mL



Fig. 5: A) Sonogram of the right ovary of camel No. showed one follicle (5.03.2025). B) Sonogram of the left ovary of camel No. 3 showed two follicles, 1.86x2.25cm and 1.19x1.08cm (5.03.2025)



Fig. 6: A) Sonogram of the right ovary of camel No. 3 showed one dominant follicle 1.89x2.29cm (5.03.2025). B) Sonogram of the right ovary of camel No. 3 showed two subdominant follicles.

and No. 5 on day 8 with 2.70ng/mL), which were lower than the values in group A (3.81ng/mL, 4.80ng/mL, and 6.62ng/mL). In experimental group B (n=6), the concentration of progesterone receptors was not determined. In group A, on the other hand, the level of the progesterone hormone was studied using ELISA. Thus, the concentration of the hormone progesterone was uniform in all tested animals. However, a slight increase in the concentration of the hormone progesterone was detected in individual animals (samples No. 2 on the 2nd day of the study with 5.20ng/mL, No. 1 on the 4th day with 4.53ng/mL, No. 3 on the 6th day with 5.06ng/mL, No. 5 and No. 6 on the 8th day with 5.76ng/mL and 5.16ng/mL, and No. 4 on the 12th day with 4.78ng/mL).

After the individual readings were analyzed, group-wise mean concentrations were compared statistically to assess overall differences between regions (Fig. 7 and 8). The average serum progesterone concentration differed significantly among the three experimental groups (Kruskal–Wallis H = 98.19, $P < 0.001$). Dromedary camels from South Kazakhstan (Group A) showed the lowest mean value (1.43 ± 0.59 ng/mL), whereas camels from West Kazakhstan (Group B) and the Almaty Region (Group C) exhibited higher progesterone levels of 4.49 ± 0.41 ng/mL and 4.76 ± 0.70 ng/mL, respectively (Fig. 7).

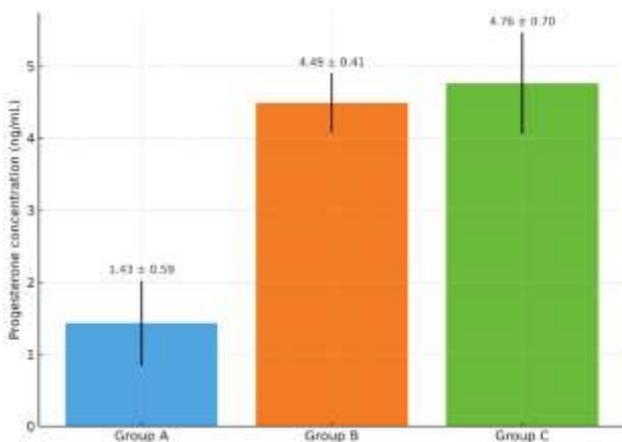


Fig. 7: Mean \pm SD of serum progesterone concentration in female camels from three regions of Kazakhstan (Groups A–C). Differences significant by Kruskal–Wallis test ($p < 0.001$).

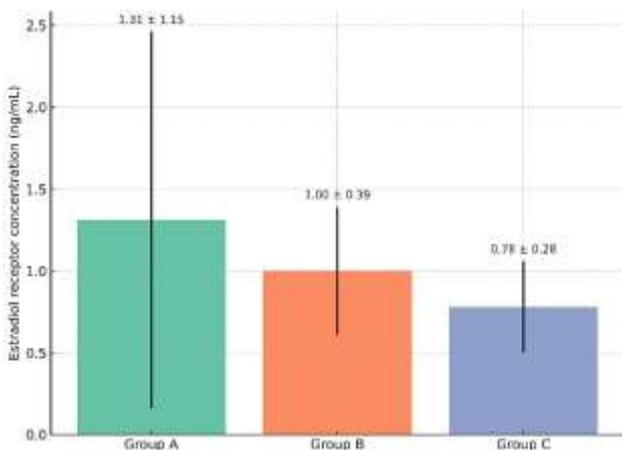


Fig. 8: Mean \pm SD of serum estradiol receptor concentration in female camels from three regions of Kazakhstan (Groups A–C). Differences significant by Kruskal–Wallis test ($p = 0.0027$).

Similarly, estradiol receptor concentrations varied significantly between groups (Kruskal–Wallis H = 11.80, $P = 0.0027$). The highest mean was recorded in South Kazakhstan Dromedaries (1.31 ± 1.15 ng/mL), followed by the West Kazakhstan group (1.00 ± 0.39 ng/mL) and the Almaty Region camels (0.78 ± 0.28 ng/mL) (Fig. 8).

These results confirm regional differences in hormonal activity during the mating season and provide a generalized view complementing the individual ELISA profiles presented in Table 1–4.

DISCUSSION

As a result of the study, we found that group A camels had peak concentrations of progesterone receptor up to 2.84ng/mL and estradiol receptor up to 6.62ng/mL, which significantly exceeded the values reported in the literature for free hormones. For example, the progesterone level in non-pregnant camels during the breeding season averages 1.97 ± 0.14 ng/mL; outside the season, it is approximately 1.15 ± 0.09 ng/mL (Amal et al. 2019). Recent observations confirm that individual camels may show receptor or hormone values exceeding population averages, especially under variable seasonal or nutritional conditions (Sohail et al. 2023). Group B animals also had high progesterone levels (up to 5.76ng/mL), despite the absence of pregnancy, which may indicate the presence of ovulatory activity or other physiological factors. Similar findings were recently described by Almushawwah et al. (2025), who reported cases of pseudopregnancy in dromedary camels characterized by transient elevations of progesterone in the absence of true conception. This suggests that short-term luteal activity or pseudopregnancy could explain the elevated values observed in our study.

Recent studies support this interpretation, showing that serum progesterone in camels can reach values around 3–6ng/mL shortly after ovulation or in early luteal phases, regardless of whether pregnancy is established. Transient increases in progesterone of this scale have been described in several field and experimental studies, indicating the necessity of repeated sampling and ultrasonography for accurate differentiation (Faraz et al. 2022; Fawzy et al. 2021). Comparable short-lived luteal phases in non-pregnant camels have also been documented in experimental breeding trials, reinforcing the need for serial hormonal monitoring (Manjunatha et al. 2022). Alternatively, elevated progesterone in non-pregnant females may arise from short-lived luteal activity or pseudopregnancy, which underscores the importance of using hormone assays in combination with ultrasound (Gherissi and Lamraoui 2021; Asadi et al. 2025).

With respect to estradiol, classic older data suggested relatively modest peaks, but more recent findings demonstrated that estradiol concentrations during estrus in dromedary camels can reach 0.15–0.17ng/mL (≈ 150 –170pg/mL) (Mohamed et al. 2021). Our receptor values, which ranged from 3.24–6.62ng/mL, are considerably higher, which can be explained by the fact that receptor concentrations reflect cellular binding capacity rather than free circulating hormone. In comparison with research data, the average level of LH in camels was 1.72 ± 0.6 u/mL outside of estrus and 5.0 ± 1.99 u/mL during estrus. Estrogens had an average level of 6.25 ± 0.46 mcg/mL

outside of estrus and 22.58 ± 3.37 mcg/mL during estrus. The average progesterone level was 6.25 ± 0.46 ng/mL outside estrus and 2.68 ± 2.31 ng/mL during estrus (Moussa et al. 2019). Similar discrepancies between receptor-based assays and circulating steroid concentrations have been reported in dromedaries and other livestock, suggesting that receptor assays provide additional sensitivity to subtle endocrine changes (Ghallab et al. 2024). This methodological distinction accounts for the apparent discrepancy and supports the view that both indicators, when interpreted together, describe the functional state of the reproductive system.

The dynamics of follicular growth revealed by ultrasound in group C are fully consistent with the model of follicular wave in camels described in the literature, characterized by induced ovulation. According to Mohamed et al. (2021), the duration of the follicular cycle in Dromedary camels averages 25.41 ± 1.36 days, while the size of dominant follicles can reach 3cm. This finding is in good agreement with the results of ultrasound studies in our work, where camel No. 1 had a dominant follicle with a diameter of 3.09×3.21 cm. Recent longitudinal studies confirm that dominant follicle growth in camels regularly reaches 2.5–3.2cm before regression or ovulation, supporting the reproducibility of our findings (Khumran et al. 2022). The literature also emphasizes that in the absence of mating, the concentration of estradiol decreases after the follicle reaches ovulatory size (Basiouni 2007), which was also observed in our animals. Such parallels confirm the reliability of the data we have collected and demonstrate the hormonal and follicular dynamics typical of Dromedary camels. Moreover, recent reviews underline that monitoring follicular waves together with serial hormone profiles is the most reliable way to evaluate reproductive status in camels, especially when ovulation is not induced (Waqas et al. 2025). These findings are in line with recent work by Mohamed et al. (2023), who showed that in non-pregnant, non-mated dromedary camels estradiol-17 β increases with follicle growth up to ~1.7cm diameter, then declines in the absence of ovulatory stimulus.

The results obtained indicate that serum progesterone and estrogen levels are biomarkers of early pregnancy detection in female camels (Vyas et al. 2004; Demissie 2019; Faraz et al. 2022). According to the results of other studies, in non-pregnant camels during the mating season, the level of the hormone progesterone was less than 3.2nmol/L (Alfurajji 1999). However, in another study, the progesterone concentration in non-pregnant camels was low, at 0.46 ± 0.12 ng/mL (Khumran et al. 2022). An analysis of our results reveals that the secretion of the estradiol receptor in the studied camels is at a basal level, with the exception of some animals in which small increases in receptor concentration were observed. This can likely be attributed to the fact that the physiological statuses of the studied camels varied. During pregnancy, as well as depending on age and physiological condition, progesterone levels in camels vary significantly (Burger et al. 2019; Abdulkareem et al. 2024).

Skidmore et al. (1995) has studied the dynamics of changes in the concentrations of the hormone's progesterone and estradiol in more detail. According to these studies, during the estrous cycle, progesterone concentration increases on days 7–9, with levels exceeding

2.6ng/mL. Our ELISA results for the progesterone content study are consistent with those of foreign scientists, and the variability among non-pregnant camels observed in our experiment corresponds to the variability highlighted by subsequent investigations (Mohamed et al. 2021; Manjunatha et al. 2022; Sohail et al. 2023; Ghallab et al. 2024).

The results of the ultrasound analysis of the ovaries of three Dromedary camels (group C) demonstrated notable activity. In camel No. 1, the left ovary was active, where the growth of two dominant follicles was detected. During the study, one dominant follicle reached a maximum diameter of 3.09×3.11 cm on the 22nd day of ultrasound scanning later. In camel's No. 2 and No. 3, the right ovary was active, where the growth of dominant follicles was detected. According to the ultrasound scan results, the growth of dominant follicles in all camels was accompanied by the growth of subdominant follicles. Studies have shown that hormones such as follicle-stimulating hormone (FSH), luteinizing hormone (LH), and insulin-like growth factor 1 (IGF1) play a crucial role in ensuring the progressive growth of the dominant follicle, while subdominant ones undergo atresia (Alharbi 2022). We obtained similar results in cows, where the growth of dominant follicles was characterized by the growth of subdominant follicles, accompanied by an increase in estradiol concentration (Turgumbekov et al. 2023). We believe that the physiological role of the simultaneous growth of subdominant follicles is to ensure the rise in estradiol concentration in peripheral blood for maximum development of the dominant follicle. This observation is supported by other scientists' research findings (Elias et al. 1984; Homeida et al. 1988; Basiouni 2007). Furthermore, contemporary data suggest that subdominant follicle development and corresponding estradiol rises are essential mechanisms ensuring sufficient endocrine signaling for ovulation in induced ovulators such as camels (Faraz et al. 2022; Turgumbekov et al. 2023; Waqas et al. 2025).

Conclusion

In the studied non-pregnant Dromedary camels (n=10) and Bactrian camels (n=5), the progesterone and estradiol receptors in 35-40% of animals showed an abrupt increase during the mating season in different geographical areas, while in the remaining camels, the progesterone content remained at the basal level without any significant fluctuations. However, the dynamics of the hormone progesterone in the studied camels (group B) were almost similar, with fluctuations from 3.71ng/mL to 5.76ng/mL. The female camels were randomly selected for the groups during the mating season, without considering the stage of the estrous cycle. Consequently, the animals exhibited a disorderly change in the dynamics of progesterone and estradiol receptor content and the hormone progesterone. It should be noted that the classical concepts of "sexual cycle" and "estrous cycle" do not correctly reflect the essence of this biological process in camels. It becomes practically impossible to study the dynamics of progesterone and estradiol receptors and the hormone progesterone in camels, as it is very difficult to determine the estrous cycle stage in camels before samples collection. Based on ultrasound scans of the camels' ovaries, it can be concluded that the three camels studied exhibited high activity in one

of the two ovaries and the presence of a dominant follicle during multiple ultrasound examinations.

DECLARATIONS

Funding: This work was carried out within the framework of the project of the Ministry of Education and Science of the Republic of Kazakhstan: "Study of the expression profile of genes associated with the maintenance of pregnancy and study of the effectiveness of using OIF to induce ovulation in Dromedary camels", AP23484301.

Acknowledgement: The authors thank the editorial team and reviewers for their constructive comments that improved the manuscript.

Conflict of Interest: The authors declare no conflict of interest.

Data Availability: Data available upon request from the corresponding author.

Ethics Statement: All procedures involving animals were carried out in accordance with the ethical standards approved by the Kazakh National Agrarian Research University Animal Ethics Committee (Protocol No. 01-398/2025).

Author's Contribution: DKh KK conceived the study and drafted the manuscript; ShK and VT designed the field survey and sampling strategy; AT and SK curated data and validated records; AK and YU provided technical support; YS supervised the project and critically revised the manuscript. All authors read and approved the final version.

Generative AI Statement: The authors declare that no Gen AI/DeepSeek was used in the writing/creation of this manuscript.

Publisher's Note: All claims stated in this article are exclusively those of the authors and do not necessarily represent those of their affiliated organizations or those of the publisher, the editors, and the reviewers. Any product that may be evaluated/assessed in this article or claimed by its manufacturer is not guaranteed or endorsed by the publisher/editors.

REFERENCES

- Abdulkareem TA, Al-Rawi HM and Abdul-Rahaman YT, 2015. Plasma profile of progesterone, estradiol-17 β and some blood biochemical attributes during different gestation periods in Iraqi female dromedary camels (*Camelus dromedarius*). *Emirates Journal of Food and Agriculture* 27(8): 643-649. <https://doi.org/10.9755/ejfa.2015.04.101>
- Abdulkareem TA, Al-Rawi HM, Abdul-Rahaman YT and Eidan SM, 2024. Pregnancy detection of iraqi She-Camels (*Camelus dromedarius*) using various techniques. *Iraqi Journal of Agricultural Sciences* 55(6): 1956-1963. <http://dx.doi.org/10.36103/whk44n85>
- Alfurajji VV, 1999. Studies on the oestrous cycle of camel (*Camelus dromedarius*). *Journal of Agricultural and Marine Sciences* 4(1): 43-46. <http://dx.doi.org/10.24200/jams.vol4iss1pp43-46>
- Alhaider AK, 2023. Insulin-like growth factor-1 improves in vitro meiotic resumption of dromedary camel (*Camelus dromedarius*) oocytes. *Animal Reproduction* 20: e20220105. <https://doi.org/10.1590/1984-3143-AR2022-0105>
- Alharbi YM, 2022. Associations between ubiquitin, follicle-stimulating hormone, and sex steroid hormones in the failed to conceive female dromedary camels raised in hot climates. *Veterinary World* 15(8): 2046-2051. <http://dx.doi.org/10.14202/vetworld.2022.2046-2051>
- Almushawwah KS, Derar DR and Ali A, 2025. Pseudopregnancy in dromedary camels: Characterization, prevalence, and clinical and hormonal properties. *Theriogenology* 235: 196–202. <https://doi.org/10.1016/j.theriogenology.2025.01.010>
- Amal A, El-Maaty A, Mohamed RM, Hozyen HF, El-Kattan AM, Mahmoud MA and Ali AH, 2019. Effect of exogenous progesterone treatment on ovarian steroid hormones and oxidant and antioxidant biomarkers during peak and low breeding seasons in dromedary she-camel. *Veterinary World* 12(4): 542-550. <https://doi.org/10.14202/vetworld.2019.542-550>
- Asadi B, Seyedasgari F and Ebadi R, 2025. Synchronization of follicular wave before superovulation in dromedary camel by means of transvaginal follicle ablation. *Domestic Animal Endocrinology* 92: 106935. <https://doi.org/10.1016/j.domaniend.2025.106935>
- Basiouni GF, 2007. Follicular wave pattern, folliculogenesis and assisted reproductive techniques in the non-pregnant female dromedary camel (*Camelus dromedarius*): A Review. *Journal of Biological Sciences* 7(6): 1038-1045. <https://doi.org/10.3923/jbs.2007.1038.1045>
- Burger PA, Ciani E and Faye B, 2019. Old World camels in a modern world – A balancing act between conservation and genetic improvement. *Animal Genetics* 50(6): 598-612. <https://doi.org/10.1111/age.12858>
- Dauda Y, Umar KS, Saka S, William A, Ahmed Y, Majama YB, Hannatu AM and Tangsom HC, 2019. Estrous cycle of induced ovulators: Lesson from the camel - A review. *Journal of Veterinary and Biomedical Sciences* 1(2): 108-125. <https://doi.org/10.36108/jvbs/8102.10.0221>
- Demissie BE, 2019. Assessment of artificial insemination in camel. *Open Journal of Animal Sciences* 9: 207-216. <http://dx.doi.org/10.4236/ojas.2019.92018>
- Elias E, Bedrak E and Yagil R, 1984. Estradiol concentration in the serum of the one humped camel (*Camelus dromedarius*) during the various reproductive stages. *General and Comparative Endocrinology* 56(2): 258-264. [https://doi.org/10.1016/0016-6480\(84\)90039-x](https://doi.org/10.1016/0016-6480(84)90039-x)
- Faraz A, Yaqoob M, Tauqir NA, Ishaq HM, Mustafa AB, Ismail A, Akbar VF, Waheed A and Nabeel MS, 2022. Utilization of hormonal biomarkers for early pregnancy diagnosis in Marecha Camel under semi-intensive management system. *Punjab University Journal of Zoology* 37(1): 77-83. <https://dx.doi.org/10.17582/journal.pujz/2022.37.1.77.83>
- Fawzy AM, Ibrahim S, Mahmoud K, Heleil BA, Ismail IE, Almadaly EA, El-Magd MA and Ramoun AA, 2021. Differential molecular and hormonal changes in oocytes, granulosa cells and follicular fluid of pregnant and non-pregnant camels. *Zygote* 29(6): 427-34. <https://doi.org/10.1017/S096719942000091X>
- Fedorova T, Brandlová K, Bičíková M, Skálová I and Lukešová D, 2015. Salivary sex steroid hormones in female bactrian camels (*Camelus bactrianus*) during different reproductive stages. *Journal of Camel Practice and Research* 22(1): 61-66. <http://dx.doi.org/10.5958/2277-8934.2015.00009.0>
- Ghallab R, Hassan MA, Askar AR, Rashad A and El-Shereif AA, 2024. A comparative study of follicular dynamics, hormonal profiles, ovarian measurements, and endometrial thickness between well-fed nulliparous and multiparous dromedary she-camels during the breeding season. *Journal of Advanced*

- Veterinary Research 14(4): 754–759.
- Gherissi DE and Lamraoui R, 2021. Reproduction management and artificial insemination in dromedary camel. In: Bouhroum S and Scandura M (eds), Sustainable Agriculture Reviews 54: Animal Biotechnology for Livestock Production 1. Cham: Springer International Publishing, pp. 55–106. https://doi.org/10.1007/978-3-030-76529-3_2
- Homeida AM, Khalil MGR and Taha AAM, 1988. Plasma concentrations of progesterone, oestrogens, testosterone and LH-like activity during oestrous cycle of the camel (*Camelus dromedarius*). *Reproduction* 83: 593-598. <https://doi.org/10.1530/jrf.0.0830593>
- Khumran AM, Bello JO, Samuel FU and Saifullah UM, 2022. Progesterone profiles and hematology of the open and pregnant one humped she camels in first and second trimesters. In: Mancha YP, Kalla DJU, Akpensuen TT, Igila TT, Luka JS and Okpanachi U (eds), NCAP 47th Annual Conference JOS 2022 Conference Proceedings, March 13-17, 2022, Federal College of Forestry, Jos, Nigeria. <https://doi.org/10.51791/njap.vi.4459>
- Lopera-Vásquez R, Uribe-García F and Rondón-Barragán I, 2022. Effect of estrous cycle phases on gene expression in bovine oviduct epithelial cells. *Veterinary World* 15(7): 1665–1675. <https://doi.org/10.14202/vetworld.2022.1665-1675>
- Manjunatha BM, Al-Hosni A and Al-Bulushi S, 2022. Effect of advancing the breeding season on reproductive performance of dromedary camels. *Theriogenology* 179: 230–236. <https://doi.org/10.1016/j.theriogenology.2021.12.007>
- Mohamed RH, El-Maaty AMA, Mohamed RS, Wehrend A, Ali F and Hussein HA, 2021. Investigations on the vaginal temperature, cycle stages, and steroid hormone concentrations during the breeding season in camels (*Camelus dromedarius*). *Veterinary World* 14(5): 1102-1108. <https://doi.org/10.14202/vetworld.2021.1102-1108>
- Mohamed RH, Yousef NA, Awad M, Mohamed RS, Ali F, Hussein HA and Wehrend A, 2023. The relationship between ovarian hormones and mast cell distribution in the ovaries of dromedary camel (*Camelus dromedarius*) during the follicular wave. *Veterinary World* 16(2): 309–316. <https://doi.org/10.14202/vetworld.2023.309-316>
- Moussa DA, Oumarou D, Bara O, Kamga WAR and Niaba T, 2019. Female camel hormonal profile during the estrous cycle in the sahelian zone of Mali. *Mirror of Research in Veterinary Sciences and Animals* 8(1): 36-47. <http://dx.doi.org/10.22428/mrvsa-2019-00814>
- Niasari-Naslaji A and Nikjou D, 2023. Superovulation in camel: State of the art. *International Journal of Livestock Research* 30(1): 19–24. <https://doi.org/10.5958/2277-8934.2023.00003.6>
- Pineda MH, 2003. Female Reproductive System. In: Pineda MH and Dooley MP (eds), McDonald's Veterinary Endocrinology and Reproduction, 5th Ed. Iowa State Press, Blackwell Publishing Company, Ames, IA, USA, pp: 303.
- Price CA and Estienne A, 2018. The life and death of the dominant follicle. *Animal Reproduction* 15(1): 680-690. <http://dx.doi.org/10.21451/1984-3143-AR2018-0030>
- Skidmore JA, 2011. Reproductive physiology in female Old World Camelids. *Animal Reproduction Science* 124 (3-4): 148-154. <https://doi.org/10.1016/j.anireprosci.2010.08.023>
- Skidmore JA, Billah M and Allen WR, 1995. The ovarian follicular wave pattern in the mated and non-mated dromedary camel (*Camelus dromedarius*). *Journal of Reproduction and Fertility Suppl* 49: 545-548.
- Sohail T, Farhab M, Zhang L, Kang Y, Sun X, Ji D and Li Y, 2023. Ovarian dynamics and changes in estradiol-17 β and progesterone relationship with standing estrus, preovulatory follicles, and ovulation using single prostaglandin F2 α injection in Barbari goats. *Veterinary Sciences* 10(10): 624. <https://doi.org/10.3390/vetsci10100624>
- Turgumbekov A, Koibagarov K, Alimbekova M, Bimenova Z and Ussenbekov Y, 2023. Results of ultrasound studies of the growth dynamics of dominant, subdominant follicles and determination of estradiol concentration in the preovulatory period in cows. *International Journal of Veterinary Science* 12(5): 680-689. <https://doi.org/10.47278/journal.ijvs/2023.036>
- Vyas S, Rai AK, Sahani MS and Khanna ND, 2004. Use of real-time ultrasonography for control of follicular activity and pregnancy diagnosis in the one humped camel (*Camelus dromedarius*) during the non-breeding season. *Animal Reproduction Science* 84(1-2): 229-233. <https://doi.org/10.1016/j.anireprosci.2003.11.006>
- Waqas MS, Anouassi A and Tibary A, 2025. Manipulation of ovarian activity in camelids. *Clinical Theriogenology* 17: 36–48. <https://doi.org/10.58292/CT.v17.11652>
- Zarrin M, Riveros JL, Ahmadpour A, de Almeida AM, Konuspayeva G, Vargas-Bello-Pérez E, Faye B and Hernández-Castellano LE, 2020. Camelids: New players in the international animal production context. *Tropical Animal Health and Production* 52: 903-913. <https://doi.org/10.1007/s11250-019-02197-2>