Natural Resources for Human Health
eISSN: 2583-1194

Original Research

Received: 02 August 2026
Revised: 07 October 2026
Accepted: 24 October 2026

Natural Resources for Human Health 2026, Vol. 6 (6): 463–476

KEYWORDS:
Dormedary camel, Ovarian morphology, Progesterone, Oestradiol, Reproductive status.

Ovarian Morphology, Body Weight and Steroid Hormones in Female Dromedary camels

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ABSTRACT: The present work was done to investigate the interrelationship between estimated body weight, reproductive tract morphometry, ovarian anatomical structures and serum oestradiol (E2) and progesterone (P4) in the she-camel (Camelus dromedarius). Forty-two she-camels (24 Sahraoui, 12 Sahraoui × Chaambi and 6 Targui; 0.5–24 years old) were examined. Body weight was estimated by the barymetric formula of Boué (1949) from height at the withers, thoracic circumference and abdominal circumference. The genital tract and both ovaries were weighed, each ovary was classified as follicle, corpus luteum (CL), cyst, hydrobursitis or no structure detected (NSD), and E2 and P4 were assayed. Estimated body weight averaged 432.3 ± 15.5 kg. Total ovarian weight increased with body weight (rho = 0.57, P < 0.001), whereas genital tract weight did not (rho = 0.21, P = 0.23) and followed uterine condition (median 2, 027 g with involution, abortion or endometritis against 574 g in the others). One third of the ovaries (33.3%) were NSD, and ovarian weight differed among structural classes (P < 0.0001), the five cystic ovaries weighing 114.8 ± 42.6 g against 4.4 ± 0.6 g for NSD ovaries. Left and right ovaries did not differ in weight or in luteal tissue. Serum E2 (31.8 ± 5.2 pg/ml) and P4 (1.47 ± 0.30 ng/ml) were low. P4 exceeded 1 ng/ml in 14 of 40 she-camels, but it was unrelated to the presence of a CL (kappa = −0.03), only 5 she-camels showing both. In an age-adjusted analysis of 39 she-camels, body weight was modestly related to ovarian weight (elasticity 1.35–1.57), the two ovaries varied together (partial rho = 0.44) and uterine weight was independent of body weight, ovarian weight and age. It could be concluded that body size, organ weights, ovarian anatomy and steroid levels give complementary and not interchangeable information on the reproductive status of the she-camel.

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INTRODUCTION

The she-camel (*Camelus dromedarius*) is a seasonal breeder and an induced ovulator, with late sexual maturity and low reproductive rates (Skidmore, 2011; Monaco et al., 2015), and annual fertility of about 54% has been reported in extensively managed Algerian herds (Kelanemer et al., 2025). Judging the reproductive status of an individual female is therefore central to herd management, and the ovary is its main anatomical and endocrine reference.

Anatomically, ovarian size and weight depend on what the ovary carries. In Egyptian dromedaries, the presence of a corpus luteum (CL) significantly affected ovarian morphometry, and the left ovary tended to be larger than the right (El-Sanea and Soliman, 2025). Ovarian activity also varies with season, age and body condition (Hussein et al., 2008), and cysts and other lesions are common in Algerian and Ethiopian dromedaries (Bekkouche et al., 2022; Getahun et al., 2021).

The endocrine picture is less direct. In well-fed nulliparous and multiparous she-camels, progesterone (P4) remained basal throughout the follicular waves, whereas oestradiol (E2) and FSH peaked in the mature phase (Ghallab et al., 2024). Serum E2, P4 and IGF-I did not differ between camels with different ovulatory-sized follicles, even though follicular fluid P4 and IGF-I rose in follicles of 18–30 mm (Kafi et al., 2014). At tissue level, receptor expression and hormone secretion in the she-camel ovary were not always correlated (Saleh et al., 2012). Even so, a serum P4 threshold of 1 ng/ml is widely used to separate luteal from non-luteal animals (Manjunatha et al., 2012), for example to assign 86 camels to follicular or luteal groups in a histological study of the uterus and vagina (Majama et al. (2023)).

Anatomical findings and serum steroids are therefore usually interpreted as if they agree. Whether they do in the same she-camel, and how they relate to body size and to the weight of the genital tract, is rarely tested. Body weight is the usual reference for organ weights, but camels are seldom weighed, so it is estimated indirectly from body measurements (barymetry), for which the classic North African equation is that of Boué (1949) (Babelhadj et al., 2021; Boujenane, 2019).

The first aim of the current study was to estimate the body weight of she-camels by barymetry and to relate it to the weight of the genital tract and ovaries, in absolute terms and as relative indices. The second aim was to describe the macroscopic structures of the ovaries and the serum E2 and P4 in relation to them. The third aim was to determine whether body size, organ weights, ovarian anatomy and steroid concentrations are associated with one another and whether they provide complementary information on the reproductive status of the she-camel.

MATERIALS AND METHODS

The animals.

The current study was conducted on 42 female dromedary camels in Algeria, comprising 24 Sahraoui, 12 Sahraoui × Chaambi crossbred, and 6 Targui camels. The animals were sampled during the breeding season at the El Oued Regional Royal Slaughterhouse, Algeria, from June 2024 to September 2026.

Age. Age was estimated in years based on dental examination, considering tooth eruption, replacement, and wear, following Seddik (2023). The median age was 14 years (range: 0.5–24 years), and two female dromedary camels were younger than 3 years. For statistical comparisons, the animals were divided into three age groups: ≤8 years (n = 7), >8 to 15 years (n = 18), and >15 years (n = 17).

Body measurements and body weight.Body measurements included height at the withers (HW), thoracic circumference (TC) and abdominal circumference (AC), all measured in centimetres using a measuring tape. Live body weight (BW, kg) was estimated using the barymetric formula of Boué, 1949. BW = 53 × TC × AC × HW, with all three measurements expressed in metres. The three measurements were available for 38 of the 42 female dromedary camels; therefore, BW was estimated for these 38 animals.

Genital tract and ovaries. The genital tract, comprising the uterus, cervix and vagina, was weighed (g) after dissection using a digital balance. Both ovaries were weighed individually (g) using a digital balance and examined macroscopically. Ovarian measurements, including length, width and thickness, were recorded in centimetres using a Vernier caliper. The diameter of the largest follicle (cm) and of the corpus luteum (CL, cm) was recorded for each ovary.

Each ovary was assigned to one structural class, in the following order of priority: cyst, hydrobursitis, follicle with CL, CL, follicle, or NSD (no structure detected) when no follicle, CL, cyst or hydrobursitis was recorded. Cysts and hydrobursitis were identified from the clinical observations recorded for the female dromedary camel and the corresponding ovarian side.

Uterine conditions recorded included pregnancy, uterine involution (including 12 days postpartum), abortion, dystocia and endometritis.

For hormonal analysis, each female dromedary camel was assigned to one ovarian status: cyst (any cystic ovary), CL (a CL in either ovary), or, when neither was present, the class corresponding to its largest follicle, adapted from the size classes of Hussein et al., 2008. inactive (no follicle or follicle ≪3 mm), growing (3–9 mm), mature (10–19 mm), and over-mature or aged (20–30 mm).

Blood sampling and hormonal assays. Blood samples were collected from the jugular vein into plain tubes without anticoagulant. Serum was separated and used immediately for hormonal analysis. Serum estradiol (E2; pg/mL) and progesterone (P4; ng/mL) concentrations were measured using the enzyme-linked immunosorbent assay (ELISA). E2 concentrations were available for 39 she-camels, whereas P4 concentrations were available for 40. A serum P4 concentration greater than 1 ng/mL was considered indicative of luteal activity, following the threshold used to describe follicular waves in the dromedary camel (Manjunatha et al., 2012).

Relative organ-weight indices. The genital tract index (GTI) was the genital tract weight expressed as a percentage of estimated body weight, and the ovarian index (OWI) was the sum of the weights of the two ovaries divided by estimated body weight and expressed as grams per 100 kg. Total ovarian weight was calculated only when both ovaries had been weighed.

Data handling. Data-handling decisions were set before analysis. The identifier of she-camel 3, recorded as 0, was corrected to 3. Ovarian weights of 0 g (both ovaries of one she-camel) were treated as missing. Follicle sizes recorded as several values or as text (for example "10 - 2.5") were replaced by the largest value. Two height values above 230 cm (247 and 286 cm) were retained, with a sensitivity analysis excluding them. Pairwise deletion was used, so the number of she-camels differs among analyses and is given with each result; 30 she-camels had complete data for body weight, genital tract weight, ovarian weight and both hormones.

Supplementary age-adjusted analysis. A supplementary analysis, prepared separately in R 4.3.3, examined the relationships among estimated live body weight (LBW), uterine weight (UW), left ovarian weight (LOW) and right ovarian weight (ROW) with adjustment for age, in a dataset of 39 she-camels aged 4 to 24 years (22 Sahraoui, 11 Sahraoui × Chaambi and 6 Targui). In this dataset LBW equalled Boué's formula exactly, so LBW is a deterministic function of TC, AC and HW and was never entered in the same model as these measurements. Ovarian weights came from she-camels with cystic ovarian disease and other pathologies. Three extreme ovarian weights were winsorised (left ovary of one she-camel, 90 to 58 g; right ovaries of two, 276 and 116 to 54 g) and seven missing values were imputed with the median of the observed values (UW 602 g for five she-camels; LOW 7 g and ROW 6 g for one she-camel); eight she-camels were affected, and a sensitivity analysis excluded them. Pearson correlations of ln-transformed variables, raw and partial (adjusted for age), and Spearman correlations, raw and partial, were corrected with Holm's method over the six pairs. Log–log linear models including age as a covariate (ln UW on ln LBW; ln LOW on ln LBW; ln ROW on ln LBW; ln LOW on ln ROW; ln UW on ln LBW, ln LOW and ln ROW) were fitted with ordinary least squares (OLS) and heteroscedasticity-robust (HC3) standard errors; the coefficient of a ln-transformed predictor is an elasticity, with 1 meaning strict proportionality. Diagnostics were the Shapiro–Wilk, Breusch–Pagan and White tests, variance inflation factors and Cook's distance. Sensitivity analyses added breed, excluded the eight modified she-camels, added a quadratic age term and used a bootstrap of 2, 000 case resamples. With 39 she-camels, the smallest partial correlation detectable with 80% power was about 0.44.

Statistical analysis. The data are presented as mean ± standard error (SE) with the range, and as median (interquartile range, IQR) where the distribution was skewed. Because most variables were skewed, non-parametric methods were used. Left and right ovaries of the same she-camel were compared with the Wilcoxon signed-rank test and the presence of a structure on each side with an exact McNemar test. Groups were compared with the Mann–Whitney U test, the Kruskal–Wallis test followed by Dunn's test with Bonferroni correction, or Fisher's exact test, and associations were assessed with Spearman's rank correlation. Agreement between two binary indicators was assessed with Cohen's kappa. Tests were two-sided and $P < 0.05$ was considered significant. Apart from Dunn's test, no correction for multiple testing was applied, so correlations should be read as exploratory. Analyses were run in Python 3.12 with SciPy 1.17.

Literature. Scopus-indexed studies on the ovarian morphology, hormones and body measurement of dromedary camels were identified through targeted searches of publisher platforms, repositories and bibliographic aggregators, using combinations of

the terms camel*, dromedar*, ovar*, progesterone, oestradiol, barymetr*, body weight and Algeria*, and indexing was checked from journal listings or publisher information; searches were closed in October 2026. A selection of the studies retrieved is cited for comparison, and the literature was not appraised for quality.

Ethical considerations. The study used material from female dromedary camels sampled at the El Oued Regional Royal Slaughterhouse. The formal ethics approval or exemption status is addressed in the Ethical approval statement below and must be confirmed by the authors before submission.

RESULTS

The she-camels had a mean age of 13.6 ± 0.9 years. Estimated body weight averaged 432.3 ± 15.5 kg (range 216.1–595.3 kg) and did not differ among breeds (Sahraoui 435.1 ± 20.9 kg, Sahraoui × Chaambi 434.2 ± 28.5 kg, Targui 418.4 ± 43.4 kg; Kruskal–Wallis P = 0.97), as shown in Table 1. Estimated body weight was closely related to the three measurements used to calculate it (TC rho = 0.83, AC rho = 0.77, HW rho = 0.73; all P < 0.001), and TC and AC were correlated (rho = 0.83). Body weight increased with age (rho = 0.40, P = 0.014, n = 38), but the association weakened to rho = 0.29 (P = 0.08) when the two animals under 3 years were excluded.

Table 1. Age, biometric measurements, estimated body weight, organ weights and relative indices of the she-camels (mean ± SE and range).

Variable	n	Mean ± SE	Range
Age (years)	42	13.6 ± 0.9	0.5–24.0
Estimated body weight (kg)	38	432.3 ± 15.5	216.1–595.3
Genital tract weight (g)	36	869 ± 141	111–4, 580
Left ovary weight (g)	39	11.1 ± 2.6	2–90
Right ovary weight (g)	39	18.3 ± 7.5	1–276
Total ovarian weight (g)	39	29.4 ± 8.0	4–289
Genital tract index (% of body weight)	33	0.21 ± 0.04	0.04–1.34
Ovarian index (g per 100 kg)	36	6.14 ± 1.97	0.85–70.95

Breeds in the study: Sahraoui n = 24, Sahraoui × Chaambi n = 12, Targui n = 6. Body weight estimated with the formula of Boué (1949). Indices are defined in Materials and methods.

Genital tract weight was highly variable (median 591 g, IQR 443–833) and reflected uterine condition. Among she-camels with no uterine condition noted (n = 32) the tract weighed a median of 574 g (IQR 408–662), whereas the four weighed tracts with involution, abortion or endometritis weighed 2, 027 g (IQR 1, 594–2, 938; Mann–Whitney P = 0.004); the two pregnant she-camels could not be weighed. Eight tracts exceeded 1, 000 g, including one of 4, 580 g with endometritis and one of 2, 391 g at 12 days postpartum. Total ovarian weight increased with estimated body weight (rho = 0.57, P < 0.001, n = 36; Fig. 1a;), as strongly for the left (rho = 0.47) as for the right ovary (rho = 0.49), and more strongly after the five she-camels with cysts were excluded (rho = 0.65, n = 33). The association persisted after excluding the two unusual height values (rho = 0.54) and, in addition, animals under 3 years (rho = 0.51). Genital tract weight was unrelated to body weight (rho = 0.21, P = 0.23; Fig. 1b), and no association appeared in the sensitivity analyses (rho = 0.06 to 0.29). Neither relative index was related to body weight (GTI rho = −0.02; OWI rho = 0.29, P = 0.09, and rho = 0.32, P = 0.07 without cystic she-camels). Left and right ovarian weights were positively correlated (rho = 0.48, P = 0.002, n = 39).

Natural Resources for Human Health
eISSN: 2583-1194

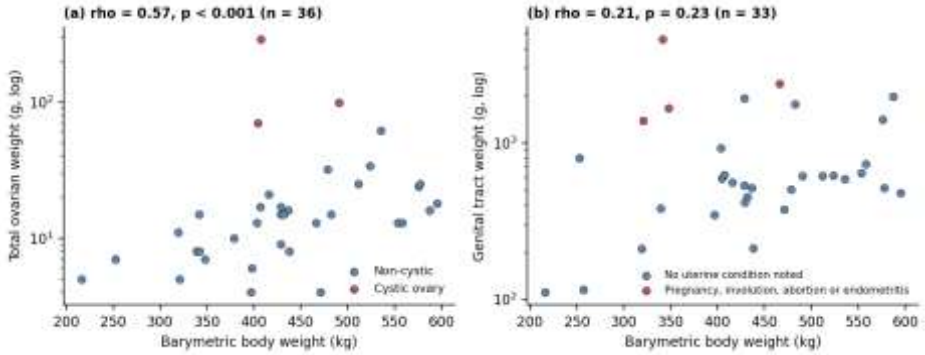


Fig. 1. Estimated body weight in relation to (a) total ovarian weight and (b) genital tract weight (logarithmic scales). Spearman coefficients are shown for all she-camels.

Of the 84 ovaries, 28 (33.3%) were NSD, 14 on each side, and both ovaries were NSD in seven she-camels (Table 2). Follicles alone were found in 33 ovaries and a CL alone in 13; a follicle with a CL occurred in three ovaries, hydrobursitis in two and a cyst in five. The five cystic she-camels (11.9%) had a cyst in the left ovary in two and in the right in three, and the two she-camels with hydrobursitis had it on one side each. Luteal tissue was found in 15 she-camels (35.7%): in the left ovary in 9, in the right in 7 and in both in one. There was no left–right difference in the presence of a CL (left only 8, right only 6; exact P = 0.79) or of a follicle (19 left, 23 right; exact P = 0.42), and left and right ovaries did not differ in weight (median 7.0 against 6.0 g; Wilcoxon P = 0.81, left heavier in 20 pairs and right heavier in 16, n = 39; P = 0.50 without cystic she-camels). The CL diameter averaged 1.7 cm (range 0.8–4.2 cm, n = 16).

Table 2. Distribution of ovarian structures by side and ovarian weight by structural class (counts and percentages per side; weight summaries based on available ovary-level data).

Ovarian structure	Right ovary	Left ovary	Both ovaries (n = 84)	Weight n	Mean ± SE (range), g	Median (IQR), g	Dunn
Follicle only	17 (40.5)	16 (38.1)	33 (39.3)	33	8.7 ± 1.0 (2–27)	7.0 (5.0–11.0)	b
Follicle with CL	2 (4.8)	1 (2.4)	3 (3.6)	3	24.7 ± 14.7 (8–54)	12.0 (10.0–33.0)	bc
Corpus luteum only	5 (11.9)	8 (19.0)	13 (15.5)	13	6.8 ± 1.0 (1–14)	7.0 (5.0–9.0)	ab
Cyst	3 (7.1)	2 (4.8)	5 (6.0)	5	114.8 ± 42.6 (34–276)	90.0 (58.0–116.0)	c
Hydrobursitis	1 (2.4)	1 (2.4)	2 (2.4)	2	13.5 ± 4.5 (9–18)	13.5 (11.2–15.8)	–
No structure detected (NSD)	14 (33.3)	14 (33.3)	28 (33.3)	22	4.4 ± 0.6 (2–10)	3.5 (2.0–5.0)	a

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Ovarian structure	Right ovary	Left ovary	Both ovaries (n = 84)	Weight n	Mean ± SE (range), g	Median (IQR), g	Dunn
She-camels with any CL	7	9	Exact McNemar P = 0.79	—	—	—	—
She-camels with any follicle	23	19	Exact McNemar P = 0.42	—	—	—	—

CL = corpus luteum. The priority of classification is given in Materials and methods. "Any follicle" includes follicles recorded in cystic or hydrobursitic ovaries; "any CL" includes follicle with CL. Only ovaries with a recorded weight (n = 78). Classes sharing a letter do not differ (Dunn test, Bonferroni-adjusted P > 0.05); hydrobursitis (n = 2) was not included in the test. Kruskal–Wallis P < 0.0001.

Ovarian weight differed among structural classes (Kruskal–Wallis P < 0.0001 for the five classes with at least three ovaries; Table 2). Cystic ovaries were by far the heaviest (median 90 g, IQR 58–116, range 34–276 g), against 3.5 g for NSD ovaries. NSD ovaries were lighter than ovaries with a follicle (P = 0.01), with a follicle and a CL (P = 0.04) and with a cyst (P < 0.0001), but not than ovaries with a CL alone (P = 0.48), and cystic ovaries were heavier than ovaries with a follicle (P = 0.03) or a CL (P = 0.02). Across the 42 ovaries bearing a follicle, ovarian weight was strongly related to follicle diameter (rho = 0.80, P < 0.001), and the relationship held without cystic ovaries (rho = 0.71, n = 37). Weight was also related to CL diameter (rho = 0.53, P = 0.03, n = 16), but ovaries with a CL were not significantly heavier than ovaries with a follicle only or with no structure (median 8.0 against 6.0 g; P = 0.20). The five cystic she-camels (she-camels 4, 21, 33, 36 and 40; aged 9 to 20 years) had cysts of 3.2 to 10 cm, and their cystic ovaries weighed 58, 276, 90, 34 and 116 g. Their total ovarian weight had a median of 99 g against 13 g in the other she-camels (P < 0.001), the heavy ovary being on the side of the cyst in every case. They did not differ from the others in estimated body weight (median 407 against 429 kg; P = 1.0, body weight being available for three of the five) or in age (17 against 14 years; P = 0.58).

Serum E2 averaged 31.8 ± 5.2 pg/ml (range 4.5–170.3; n = 39) and P4 1.47 ± 0.30 ng/ml (range 0.18–8.95; n = 40). Eleven E2 values lay between 14.5 and 16 pg/ml, a cluster that may correspond to the lower limit of assay sensitivity, and five she-camels had E2 above 50 pg/ml (she-camels 5, 8, 10, 11 and 23; maximum 170.3 pg/ml in she-camel 5, in which tertiary follicles were noted on histology). P4 exceeded 1 ng/ml in 14 of 40 she-camels (35%). E2 and P4 were unrelated (rho = 0.02, P = 0.89). In relation to ovarian status (Table 3), E2 was highest in she-camels with inactive ovaries (41.6 ± 12.7 pg/ml) and with a CL (38.7 ± 13.1 pg/ml), and lowest in those with over-mature follicles (16.4 ± 0.5 pg/ml), while E2 of she-camels with mature follicles (21.7 ± 2.0 pg/ml) did not exceed that of the others. P4 was highest in she-camels with over-mature follicles (2.61 ± 1.16 ng/ml) and with a CL (1.71 ± 0.68 ng/ml) and lowest in cystic she-camels (0.97 ± 0.14 ng/ml). None of these differences was significant (Kruskal–Wallis P = 0.19 for E2 and P = 0.54 for P4), and the groups with growing follicles (n = 2) and over-mature follicles (n = 4) were very small. E2 was weakly related to the diameter of the largest follicle (rho = 0.36, P = 0.07, n = 27), and cystic she-camels tended to have higher E2 than the others (medians 32.2 against 18.4 pg/ml; P = 0.051) but similar P4 (P = 0.49).

Table 3. Serum oestradiol (E2) and progesterone (P4) in relation to ovarian status (mean ± SE and range).

Ovarian status	n (E2)	E2 (pg/ml)	n (P4)	P4 (ng/ml)	Ovarian weight (g)
Inactive (no follicle or < 3 mm)	6	41.6 ± 12.7 (15.0–88.3)	6	1.12 ± 0.31 (0.18–2.24)	7.8
Growing follicle (3–9 mm)	1	20.6	1	0.20	11.5
Mature follicle (10–19 mm)	9	21.7 ± 2.0 (14.5–32.6)	9	1.21 ± 0.44 (0.23–4.34)	13.7

Natural Resources for Human Health
eISSN: 2583-1194

Ovarian status	n (E2)	E2 (pg/ml)	n (P4)	P4 (ng/ml)	Ovarian weight (g)
Over-mature or aged follicle (20–30 mm)	4	16.4 ± 0.5 (15.5–17.7)	4	2.61 ± 1.16 (0.43–5.77)	21.5
Corpus luteum (any CL)	14	38.7 ± 13.1 (4.5–170.3)	15	1.71 ± 0.68 (0.20–8.95)	17.1
Cyst	5	33.6 ± 3.8 (23.2–45.7)	5	0.97 ± 0.14 (0.51–1.30)	125.4

Status assigned in the order cyst, corpus luteum, then largest follicle class (Materials and methods). Mean total ovarian weight is given in the last column. Kruskal–Wallis P = 0.19 (E2) and P = 0.54 (P4) for the classes with at least three observations.

P4 did not differ between she-camels with a CL (median 0.67 ng/ml, n = 15) and those without (0.87 ng/ml, n = 25; P = 0.48), and E2 did not differ either (15.8 against 21.9 pg/ml; P = 0.30). Among the she-camels with a CL, P4 was at or below 1 ng/ml in 10 of 15, including both pregnant she-camels (0.88 and 0.36 ng/ml, each with a CL of 1.8 cm) and all five with uterine involution, abortion, dystocia or endometritis (0.21–0.96 ng/ml). Conversely, P4 exceeded 1 ng/ml in 9 of 25 she-camels without a CL, with values up to 5.77 ng/ml (she-camels 34 and 30: 5.77 and 4.34 ng/ml). In five of these nine the largest follicle measured 2 cm or more or a cyst was present (she-camels 4, 17, 28, 33 and 34), against four of the 16 without a CL and with P4 at or below 1 ng/ml (Fisher P = 0.20). Table 4 shows that anatomical luteal status and P4 above 1 ng/ml agreed poorly (kappa = −0.03; Fisher P = 1.0, odds ratio 0.89; Fig. 2): five she-camels had both indicators, 10 a CL alone, nine P4 above 1 ng/ml alone and 16 neither. At least one indicator was present in 24 of 40 she-camels (60%) but both in only 5 (12.5%).

Table 4. Agreement between the presence of a corpus luteum (CL) and serum progesterone above 1 ng/ml in 40 she-camels.

	P4 > 1 ng/ml	P4 ≤ 1 ng/ml	Total
CL present	5	10	15
CL absent	9	16	25
Total	14	26	40

Cohen's kappa = −0.03; Fisher exact P = 1.0; odds ratio 0.89.

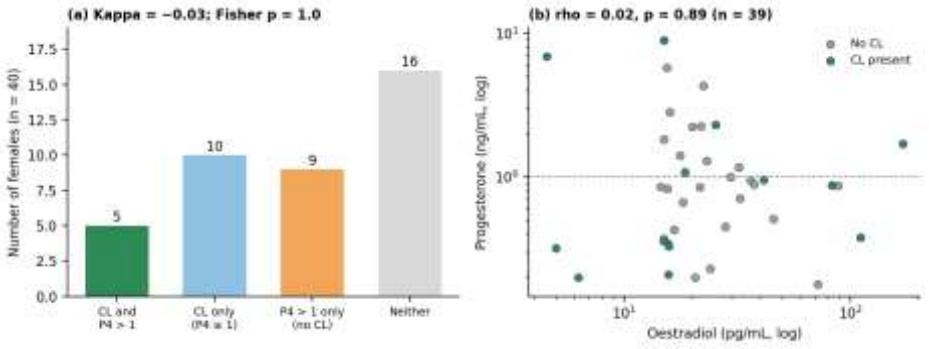


Fig. 2. Agreement between anatomical and hormonal indicators of luteal activity: (a) number of she-camels by combination of corpus luteum (CL) and P4 above 1 ng/ml; (b) E2 against P4 on logarithmic axes.

The hormones showed associations with ovarian weight and age (). Total ovarian weight correlated with E2 (rho = 0.41, P = 0.01, n = 36) and P4 (rho = 0.34, P = 0.04, n = 37), and the ovarian index showed the same pattern (rho = 0.41 and 0.37). Without the cystic she-camels the association with P4 persisted (rho = 0.39, P = 0.03) but that with E2 weakened (rho = 0.27,

P = 0.14). Genital tract weight was unrelated to either hormone. P4 rose with age (rho = 0.45, P = 0.004, n = 40; rho = 0.40 among animals of 3 years or more) and with body weight (rho = 0.33, P = 0.04), although the latter association weakened to rho = 0.28 (P = 0.10) among adults. E2 was unrelated to age and body weight.

Spearman rank correlations among body weight, organ weights, hormones and age.

E2 = oestradiol; P4 = progesterone. Correlations are exploratory and were not adjusted for multiple testing. Adults = animals of 3 years or more.

By age group (Table 5), the ovaries of she-camels of more than 8 to 15 years were the least often NSD (25.0% against 42.9% and 38.2%) and most often carried a CL (25.0% against 14.3% and 14.7%), but the differences were not significant (chi-square for NSD, P = 0.36). Cysts were found in no she-camel up to 8 years, in two of 18 between 8 and 15 years and in three of 17 above 15 years. Body weight (P = 0.07) and total ovarian weight (P = 0.06) tended to differ among groups, E2 did not (P = 0.61), and P4 differed (Kruskal–Wallis P = 0.033), being 0.86 ± 0.30, 0.88 ± 0.23 and 2.36 ± 0.65 ng/ml in the three groups. P4 exceeded 1 ng/ml in 1 of 6, 5 of 18 and 8 of 16 she-camels respectively (Fisher P = 0.18 for the oldest group against the others).

Table 5. Ovarian structures, body weight, organ weights and hormones by age group.

	≤ 8 years	> 8–15 years	> 15 years	Kruskal–Wallis P
She-camels (ovaries), n	7 (14)	18 (36)	17 (34)	
Ovaries NSD, n (%)	6 (42.9)	9 (25.0)	13 (38.2)	0.36 (chi-square)
Ovaries with follicle only, n (%)	5 (35.7)	16 (44.4)	12 (35.3)	
Ovaries with CL, n (%)	2 (14.3)	9 (25.0)	5 (14.7)	
Ovaries with cyst, n (%)	0	2 (5.6)	3 (8.8)	
Ovaries with hydrobursitis, n (%)	1 (7.1)	0	1 (2.9)	
Body weight (kg)	363 ± 45	436 ± 21	464 ± 21	0.07
Total ovarian weight (g)	10.0 ± 3.0	33.6 ± 15.6	32.1 ± 9.1	0.06
Genital tract weight (g)	628 ± 243	988 ± 189	871 ± 272	0.14
E2 (pg/ml)	48.0 ± 18.8	35.0 ± 9.7	23.2 ± 2.5	0.61
P4 (ng/ml)	0.86 ± 0.30	0.88 ± 0.23	2.36 ± 0.65	0.033

Mean ± SE. NSD = no structure detected; CL = corpus luteum; E2 = oestradiol; P4 = progesterone. The ovarian structure classes include the follicle with CL in the CL class.

The supplementary age-adjusted analysis in 39 she-camels (Table 6) gave the following results. Estimated body weight was 443.6 ± 13.2 kg and approximately normally distributed (Shapiro–Wilk P = 0.51), whereas the organ weights were strongly skewed (all P < 0.001): UW had a median of 602 g (IQR 511–768), LOW 7.0 g (IQR 5.0–10.0) and ROW 6.0 g (IQR 4.0–9.0), with coefficients of variation of 92%, 117% and 127%. Neither breed (Kruskal–Wallis P = 0.29 to 0.71; age-adjusted analysis of covariance P = 0.62 to 0.82) nor age explained these variables; age correlated weakly with TC (rho = 0.32), HW (0.31) and body weight (0.31) and not with UW (−0.10), LOW (0.13) or ROW (0.17), and no correlation survived Holm correction (adjusted P ≥ 0.33). After adjustment for age, LBW–LOW (r = 0.33), LBW–ROW (r = 0.32) and LOW–ROW (r = 0.36) were moderately correlated (nominal P = 0.046, 0.052 and 0.027), none surviving Holm correction (adjusted P ≥ 0.16), and

adjustment for age changed the correlations by at most 0.03. Partial rank correlations were slightly stronger (LBW–LOW 0.37 and LBW–ROW 0.38, Holm P = 0.096 for both), and the association between the two ovaries (partial rho = 0.44, Holm P = 0.033) was the only one to survive correction (Table 7). UW was unrelated to LBW, ROW and, weakly, LOW.

Table 6. Supplementary dataset: age, biometrics, estimated body weight and organ weights of 39 she-camels aged 4–24 years.

Variable	Mean ± SE	Median (IQR)	Range	CV (%)	Shapiro P
Age (years)	14.1 ± 0.8	14.0 (11.0–18.5)	4.0–24.0	35.0	0.413
TC (cm)	196.5 ± 2.1	198.0 (188.0–206.0)	152–220	6.8	0.068
AC (cm)	216.7 ± 3.2	215.0 (207.5–226.0)	165–277	9.3	0.362
HW (cm)	195.4 ± 3.3	193.0 (184.5–202.5)	160–286	10.7	< 0.001
LBW (kg)	443.6 ± 13.2	431.3 (400.6–488.1)	252.6–595.3	18.6	0.506
UW (g)	873.8 ± 128.2	602.0 (511.0–768.0)	211–4, 580	91.6	< 0.001
LOW (g)	10.4 ± 2.0	7.0 (5.0–10.0)	2–58	116.7	< 0.001
ROW (g)	11.1 ± 2.2	6.0 (4.0–9.0)	1–54	127.1	< 0.001

TC, AC and HW = thoracic circumference, abdominal circumference and height at the withers; LBW = estimated live body weight; UW = uterine weight; LOW and ROW = left and right ovarian weight. UW, LOW and ROW include imputed (5, 1 and 1) and winsorised (0, 1 and 2) values. SE derived from the standard deviation (n = 39).

In the log–log models including age, LBW was unrelated to UW (β = 0.02, P = 0.97) but was positively related to the weight of both ovaries; the elasticities were 1.35 for LOW and 1.57 for ROW, so that, at constant age, a 10% higher body weight corresponded to a 13.7% higher LOW and a 16.2% higher ROW (Table 7). These coefficients were significant with robust HC3 standard errors (P = 0.001 and 0.011; Holm-adjusted P = 0.004 and 0.022) but borderline with OLS (P = 0.046 and 0.052), and their confidence intervals included 1, so that growth of the ovaries more than proportional to body weight is not demonstrated. LOW and ROW were related (β = 0.30, P = 0.010 with HC3). Neither LBW nor the ovaries explained UW in the combined model (all OLS P ≥ 0.25), and age had no effect in any model (P ≥ 0.60). The models explained little variance (R^2 = 0.004 for UW on LBW, about 0.12 for LOW and ROW on LBW, 0.14 for LOW on ROW and 0.04 for the combined UW model). Diagnostics showed no collinearity (variance inflation factor ≤ 1.25), no heteroscedasticity (Breusch–Pagan and White P > 0.19) and no influential observation (maximum Cook's distance 0.37), but non-normal residuals in four models (P = 0.003 to 0.025), which is why robust and bootstrap intervals were used. The coefficient of ln LBW was stable across the sensitivity analyses, 1.28 to 1.35 for LOW, 1.46 to 1.57 for ROW and about zero for UW, whether breed was added, the eight modified she-camels were excluded (n = 31), a quadratic age term was added or a bootstrap was used (bootstrap intervals 0.58–2.15 for LOW, 0.35–2.88 for ROW and −1.36 to 1.41 for UW).

Table 7. Supplementary dataset: relationships among LBW, UW, LOW and ROW adjusted for age (n = 39).

Relationship	Partial r (95% CI)	Partial rho (Holm P)	β (95% CI, HC3)	P (HC3 / OLS)
LBW – UW	0.01 (−0.31; 0.33)	0.06 (1.000)	0.02 (−1.40; 1.45)	0.975 / 0.969
LBW – LOW	0.33 (0.01; 0.58)	0.37 (0.096)	1.35 (0.56; 2.13)	0.001 / 0.046
LBW – ROW	0.32 (0.00; 0.58)	0.38 (0.096)	1.57 (0.38; 2.76)	0.011 / 0.052

Relationship	Partial r (95% CI)	Partial rho (Holm P)	β (95% CI, HC3)	P (HC3 / OLS)
LOW – ROW	0.36 (0.05; 0.61)	0.44 (0.033)	0.30 (0.08; 0.52)	0.010 / 0.027
UW – LOW	0.18 (−0.15; 0.47)	0.28 (0.270)	–	–
UW – ROW	−0.01 (−0.33; 0.31)	0.07 (1.000)	–	–

Pearson partial correlations on ln-transformed variables, adjusted for age. β is the coefficient (elasticity) of ln LBW for UW, LOW and ROW, and of ln ROW for LOW. HC3 = heteroscedasticity-robust standard errors; OLS = ordinary least squares.

DISCUSSION

The present study revealed that ovarian weight in the she-camel scales with estimated body weight and, much more strongly, with the structure carried by the ovary, whereas the weight of the genital tract does not scale with body weight but follows the condition of the uterus. One third of the ovaries carried no detectable structure, no left–right asymmetry was demonstrated, and the hormonal indicator of luteal activity (P4 above 1 ng/ml) did not coincide with the anatomical one (the presence of a CL). The age-adjusted analysis showed that age was not a confounder, that the two ovaries varied together and that uterine weight was independent of body size and of ovarian weight.

The estimated weights are plausible for adult dromedaries, with a mean of 432 kg and a range that includes two young animals (216 and 257 kg). Steppe-camel females averaged 482.6 ± 60.0 kg with the same formula (Babelhadj et al., 2021), and the lower mean in the present study may reflect the composition of the sample, which includes animals under 3 years and several small she-camels. The estimate depends on three measurements and is only as good as they are. The abdominal circumference includes the hump and the volume of the stomach compartments, so it reflects body condition and fill as much as morphology (Babelhadj et al., 2021), and two height values (247 and 286 cm) were outliers here, probably recording errors. The equation of Boué is not the best predictor among those compared for camels (Boujenane, 2019), and equations should ideally be built for breed, sex and age (Babelhadj et al., 2021). The estimates should therefore be taken as an index of body size and not as measured weight. That estimated weight did not differ among breeds and increased only modestly with age is consistent with a formula built on measurements in which condition and fill add noise.

Ovarian weight increased with estimated body weight (rho 0.57, and 0.65 without cysts), indicating that larger she-camels have heavier ovaries, but the relationship was not strong enough to make the relative ovarian index independent of body size (rho 0.29), and the index was inflated by cysts, which raised its median from about 3 g per 100 kg to about 20 g per 100 kg in cystic she-camels. The index therefore reflects pathology more than size. For the genital tract the picture is simpler: its weight was unrelated to body weight and was dominated by uterine condition. Tracts with involution, abortion or endometritis weighed about three and a half times more than the others, gravid tracts could not be weighed, and the heaviest tract (4, 580 g) was from a she-camel with endometritis. The postpartum uterus regresses over a period of weeks in the dromedary (Derar et al., 2014), and the length and circumference of the uterine horns are greater in winter than in summer (Ali et al., 2017), . A tract index expressed as a proportion of body weight has little value unless pregnancy and uterine disease are accounted for.

One third of the ovaries (28 of 84) were NSD, and in seven she-camels neither ovary carried a structure. This proportion is higher than the 9–12% of inactive ovaries (follicles under 3 mm) in the Egyptian abattoir series (Hussein et al., 2008), although the definitions differ. Ovarian weight reflected the structure carried, NSD ovaries being the lightest and cystic ovaries (median 90 g) an order of magnitude heavier than any other class, and it was strongly associated with follicle diameter (rho = 0.80, and 0.71 without cysts), which makes weight a simple, objective indicator of follicular status. The five cystic she-camels (11.9%) carried cysts of 3.2 to 10 cm on one side, dimensions larger than the 30–55 mm cysts described in Ethiopian dromedaries (Getahun et al., 2021); the prevalence is below the roughly one third of non-pregnant adult ovaries reported in the Oued Souf region (Bekkouche et al., 2022), but sampling frames differ. Two further she-camels had hydrobursitis, a lesion that reviews associate with chlamydial and trypanosomal infection as well as with abortion (Houssou et al., 2025); infectious status was not investigated here.

Left–right asymmetry was not found: the ovaries had similar weights and a CL was found in the left ovary in nine and in the right in seven she-camels. Functioning CL were recorded in 11.56% of left and 10.31% of right ovaries, and mature follicles

in 25.3% and 18.75%, in Egyptian she-camels (Hussein et al., 2008), non-pregnant Egyptian dromedaries showed a left-ovary weight advantage that was not significant and more follicles on the left (El-Sanea and Soliman, 2025), and Algerian slaughterhouse data indicate a left-sided bias in ovarian function with left-horn gestation (Gherissi et al., 2018; Benaissa et al., 2016). The absence of asymmetry here may reflect the small sample, the inclusion of many she-camels with low ovarian activity and the mixture of reproductive states, and it does not contradict the published left-sided bias. Both pregnant she-camels carried their CL in the left ovary, in line with left-horn gestation. The CL itself did not make ovaries heavier (8.0 against 6.0 g, P = 0.20), unlike the doubling of weight of the ovaries with a CL in pregnant Egyptian she-camels (El-Sanea and Soliman, 2025). Many of our CL were small (median 1.7 cm) and several belonged to she-camels with uterine involution or abortion, in which luteal regression is expected, so these CL are probably not equivalent to the functional CL of pregnancy.

Both hormones were low. The mean E2 (31.8 pg/ml) is in the range of 21–64 pg/ml found by Hussein et al. (2008) across ovarian structures, with similar values in the breeding and non-breeding seasons, and it is lower than the 67.7 pg/ml of the peak season of Pakistani camels (Ali et al., 2007). In the present study E2 was lowest (16.4 pg/ml) in she-camels with over-mature follicles of 20–30 mm, and in Egyptian she-camels E2 followed follicle diameter up to 19 mm and then declined to basal values in larger follicles and cysts (Hussein et al., 2008), which are thought to undergo atresia once they exceed 2 cm (Skidmore et al., 1996). The E2 of our cystic she-camels (33.6 pg/ml) was higher than the 21.5 pg/ml reported in follicular cysts by Hussein et al. (2008) and tended to exceed that of the other she-camels, which would be compatible with hormonally active large follicles, but with five animals this remains a suggestion. Hormonal and biochemical alterations have been described in dromedaries with multiple ovarian cysts (El-Badry et al., 2020), whereas in Algerian camels the follicular fluid of cystic follicles did not differ from that of pre-ovulatory follicles in the components measured (Bekkouche et al., 2022). The cluster of 11 E2 values between 14.5 and 16 pg/ml suggests that results near the lower limit of the assay may be imprecise.

The weak relation between P4 and the CL is the most striking result. In Egyptian she-camels P4 remained below 1 ng/ml except in the CL group (1.65 ± 0.19 ng/ml), because the CL is the main source of P4 (Hussein et al., 2008). The mean P4 of our CL group (1.71 ± 0.68 ng/ml) is similar, but it conceals a wide dispersion, only five of the 15 she-camels with a CL exceeding 1 ng/ml, whereas nine she-camels with P4 above 1 ng/ml had no CL in either ovary. Several explanations are possible. Many of the CL were recorded in she-camels with uterine involution, abortion, dystocia or endometritis, in which luteal regression would be expected and P4 low. In dromedaries, P4 can also exceed 1 ng/ml in follicular waves not followed by ovulation (Manjunatha et al., 2012), and CL may form spontaneously in non-mated females (Nagy et al., 2005); five of the nine she-camels with P4 above 1 ng/ml and no CL had a follicle of 2 cm or more or a cyst, which would fit luteinisation of a persistent follicle, although the difference from the other she-camels without a CL was not significant. Conversely, the two pregnant she-camels had P4 of 0.88 and 0.36 ng/ml despite a 1.8 cm CL, which is unexpected in pregnancy and calls for verification of sample handling, timing and assay performance. In slaughterhouse material the interval between blood collection and slaughter, the stress of the animal and the quality of the serum can all affect hormone results, and a single value cannot capture the dynamics of the luteal phase.

By age group, the ovaries of she-camels of more than 8 to 15 years were the least often NSD and the most often luteal, in line with the better reproductive capacity of this age group in Egyptian she-camels, in which inactive ovaries were commoner in young and old animals (Hussein et al., 2008), although the differences here were not significant. P4 was higher in the oldest group (2.36 ± 0.65 ng/ml, P = 0.033), a finding that was not accompanied by a corresponding difference in the CL and that may relate to the luteal cysts and anovulatory follicles that are commoner in aged she-camels (Hussein et al., 2008); with 17 animals and many comparisons it should be viewed as exploratory. Cysts were found in none of the young she-camels and in two and three of the middle-aged and old ones, and ovarian weight was not associated with age, in line with the absence of an age effect on ovarian size between 3 and 15 years (Ali et al., 2007) and on the occurrence of cysts (Bekkouche et al., 2022).

The principal question was whether these parameters provide complementary information on reproductive status. The answer is that they do, but in a form that requires interpretation. Body size and ovarian weight were related, so that ovarian weight can be interpreted in the light of body size; genital tract weight added information on the uterine state, independently of size; ovarian structure explained most of the variation in ovarian weight; and the hormonal profile identified different she-camels as luteal from those identified by anatomy. Combining anatomy and P4 raised the number of she-camels with evidence of luteal activity from 15 or 14 to 24 of 40. These indicators are therefore not interchangeable, and each should be interpreted with reference to the reproductive state of the she-camel (pregnant, postpartum, cystic or cycling). A practical consequence is that ovarian examination and a single hormone assay should be combined with ultrasonography (Ali et al., 2017) and repeated

sampling when reproductive status matters (Tibary, 2019), and manipulation of the breeding season, which has been evaluated elsewhere, depends on such classification (Manjunatha et al., 2022).

The supplementary analysis in 39 she-camels agrees in direction with the primary analysis but is more conservative. Age was not a confounder: it correlated weakly with the body-size measurements and not with organ weights, and adjusting for it changed the correlations by at most 0.03. Estimated body weight was modestly and positively related to the weight of both ovaries (partial r about 0.33; elasticities 1.35 and 1.57), a result that was robust to breed, to the exclusion of the modified she-camels, to a quadratic age term and to the bootstrap, but borderline with classical standard errors and not significant after Holm correction. It is best read as a probable positive association of imprecise size, and the confidence intervals include 1, so that the data do not show that the ovaries grow faster than body size. The correlations are weaker than in the primary analysis (rho 0.47 to 0.57), which is expected because the primary analysis kept the full weights of the heaviest cystic ovaries, whereas the supplementary dataset winsorised three of them, excluded the youngest animals and used a smaller set. The association between the two ovaries was the most robust result (partial rho = 0.44), in line with the primary analysis (rho = 0.48); she-camels with heavy ovaries on one side tended to have heavy ovaries on the other, although cysts were mostly unilateral in the primary dataset and the cause cannot be identified. UW was independent of body weight, of each ovary and of age, in agreement with the primary analysis in which tract weight followed uterine condition; the median imputation of five of 39 uterine weights may have attenuated any weak relationship, and with 39 she-camels only correlations of about 0.44 or more could be detected with 80% power, so non-significant results are inconclusive and not evidence of absence.

Future work should combine ultrasonography and serial blood sampling with direct weighing or standardised body measurements, document reproductive history, include histology of cysts and corpora lutea, screen for infectious agents and examine the bulls before the rutting season, as recommended for herd infertility (Houssou et al., 2025), and use sufficiently large samples of Sahraoui, Targui and crossbred she-camels to permit analysis by reproductive state. A breed-, sex- and age-specific barymetric equation for Algerian dromedaries, validated against weighbridge data, would make weight-based indices much more reliable.

CONCLUSION

It could be concluded that, in the she-camels studied, estimated body weight was associated with total ovarian weight but not with genital tract weight, which reflected uterine condition. Ovarian weight reflected the structure carried by the ovary, being greatest in cystic ovaries and closely related to follicle diameter, and one third of the ovaries showed no detectable structure. Left and right ovaries did not differ in weight or luteal tissue in this sample. Serum E2 and P4 were low, and P4 did not coincide with the presence of a CL, so that anatomy and hormones identified largely different she-camels as luteal. In the age-adjusted supplementary analysis, age did not confound any relationship, body weight was modestly and probably positively related to ovarian weight, the two ovaries varied together, and uterine weight was unrelated to body weight or ovarian weight. Barymetric body weight, tract and ovarian morphometry, ovarian anatomy and steroid hormones therefore provide complementary rather than interchangeable information on the reproductive status of the she-camel, and larger, standardised studies with ultrasonography and repeated sampling are needed to confirm and extend these observations.

Conflict of interest

The authors declare no competing interests.

Ethical approval

The study describes sampling at a regional slaughterhouse. All procedures involving animals were conducted in accordance with the applicable institutional and national guidelines for animal research. Ethical approval was obtained from the relevant authority, where applicable.

REFERENCES

[1] Ali, A., Derar, D., Alsamri, A. and Al Sobayil, F., 2017. Echography of clinically relevant disorders in the genital tract of female dromedary camels. Anim. Reprod. Sci., 182: 123–133.

[2] Ali, H.M., Qureshi, A.S., Urbinati, G., Hussain, R., Mustafa, M.Z., Ali, F., Manan, A. and Liliane, M.M., 2017. Effects of natural environment on reproductive histo-morphometric dynamics of female dromedary camel. Anim. Reprod. Sci., 181: 30–40.

[3] Ali, S., Ahmad, N., Akhtar, N., Rahman, Z. and Sarwar, M., 2007. Effect of season and age on the ovarian size and activity of one-humped camel (Camelus dromedarius). Asian-Aust. J. Anim. Sci., 20(9): 1361–1366.

[4] Babelhadj, B., Guintard, C., Benaissa, A. and Thorin, C., 2021. Caractérisation biométrique du Chameau de la steppe (Camelus dromedarius) en Algérie. Rev. Elev. Med. Vet. Pays Trop., 74(1): 37–42.

[5] Bekkouche, A., Miroud, K., Mimoune, N., Benamor, B., Kaidi, R. and Benaissa, M.H., 2022. Follicular fluid and serum biochemical and hormonal profiles of normal and cystic dromedary camel breeds. Vet. World, 15(11): 2511–2516.

[6] Benaissa, M.H., Faye, B., Youngs, C.R. and Kaidi, R., 2016. Slaughterhouse survey of culled female camels (Camelus dromedarius) in southeast Algeria: Fetal wastage and pregnancy characteristics. Emirates J. Food Agric., 28(11): 805–812.

[7] Boujenane, I., 2019. Comparison of body weight estimation equations for camels (Camelus dromedarius). Trop. Anim. Health Prod., 51: 1003–1007.

[8] Boué, A., 1949. Essai de barymétrie chez le dromadaire nord-africain. Rev. Elev. Med. Vet. Pays Trop., 1(3): 3–16.

[9] Derar, R., Ali, A. and Al-Sobayil, F.A., 2014. The postpartum period in dromedary camels: Uterine involution, ovarian activity, hormonal changes, and response to GnRH treatment. Anim. Reprod. Sci., 151(3–4): 186–193.

[10] Djeddi, K., Houssou, H., Gouasmia, Y., Rahab, H., Miloudi, L., Belgith, M. and Allag, L., 2024a. Clinical study on camel mastitis (Camelus dromedarius) at Beni Guecha area, Algeria. Egypt. J. Vet. Sci. (advance online publication).

[11] Djeddi, K., Houssou, H., Rabah, S., Ouchtati, D., Djeddoubenabid, A., Miloudi, A. and Khenenou, T., 2024b. Review on subclinical mastitis in dairy camels. J. Appl. Vet. Sci., 9(3): 50–63.

[12] El-Badry, D.A., Ibrahim, M.A. and Leil, A.Z., 2020. Hormonal and biochemical studies on female dromedary camels affected with multiple ovarian cysts. Small Rumin. Res., 188: 106138.

[13] El-Sanea, A.M. and Soliman, S.S., 2025. Ovarian morphometry and follicular population in non-pregnant and pregnant Camelus dromedaries. Egypt. J. Vet. Sci., 56(8): 1931–1937.

[14] Getahun, A.M., Hunderra, G.C., Gebrezihar, T.G., Boru, B.G., Desta, N.T. and Ayana, T.D., 2021. Comparative study on lesions of reproductive disorders of cows and female dromedary camels slaughtered at Addis Ababa, Adama and Akaki abattoirs with bacterial isolation and characterization. BMC Vet. Res., 17: 134.

[15] Ghallab, R.S., Hassan, M.A.N., Askar, A.R., Rashad, A.M.A. and El-Shereif, A.A., 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. J. Adv. Vet. Res., 14(4): 754–759.

[16] Gherissi, D.E., Afri-Bouzebda, F., Bouzebda, Z. and Bonnet, X., 2018. Are female camels capital breeders? Influence of seasons, age, and body condition on reproduction in an extremely arid region. Mamm. Biol., 93: 124–134.

[17] Houssou, H., Djeddi, K., Djeddou-Benabid, A. and Ouachtati, D., 2025. A review on the role of dromedary bulls on infertility of camel herds. Stud. Sci. Sci., 43(3): 90–101.

[18] Hussein, M.M., El-Agawany, A.A. and Amin, K., 2008. Ovarian activity of she-camel (Camelus dromedarius) in relation to season, hormonal pattern, age and body condition scores. Beni-Suef Vet. Med. J., 18(2): 1–9.

[19] Kafi, M., Mesbah, F., Davoodian, N. and Kadivar, A., 2014. Fine structures of the oocyte in relation to serum, follicular fluid steroid hormones and IGF-I in the ovulatory-sized follicles in one-humped camel (Camelus dromedarius). Avicenna J. Med. Biotechnol., 6(1): 57–61.

[20] Kelanemer, R., Adel, D., Medrouh, B., Belala, R., Sellali, S., Saidi, A., Kalem, A., Rahmoune, Y., Dellal, N., Fettata, S., Moula, N. and Ziam, H., 2025. She-camel (Camelus dromedarius) reproductive status and biochemical blood parameters assay in extensive breeding in southern Algeria. Livest. Sci., 292: 105646.

[21] Majama, Y.B., Zakariah, M., Maidala, H.M.B., Adamu, L. and Kwari, H.D., 2023. Histology of the one-humped camel's uterus and vagina during the follicular and luteal phases of the oestrous cycle. Veterinaria 72(3), 253–260. https: //doi.org/10.51607/22331360.2023.72.3.253.

[22] Manjunatha, B.M., Al-Hosni, A. and Al-Bulushi, S., 2022. Effect of advancing the breeding season on reproductive performance of dromedary camels. Theriogenol., 179: 230–236.

[23] Manjunatha, B.M., Pratap, N., Al-Bulushi, N.S. and Hago, B.E., 2012. Characterisation of ovarian follicular dynamics in dromedary camels (Camelus dromedarius). Theriogenol., 78(5): 965–973.

[24] Monaco, D., Padalino, B. and Lacalandra, G.M., 2015. Distinctive features of female reproductive physiology and artificial insemination in the dromedary camel species. Emirates J. Food Agric., 27(4): 328–337.

[25] Nagy, P., Juhasz, J. and Wernery, U., 2005. Incidence of spontaneous ovulation and development of the corpus luteum in non-mated dromedary camels (Camelus dromedarius). Theriogenol., 64(2): 292–304.

[26] Saleh, A.M., Abdelhafez, E.A. and Derar, D.R.I., 2012. Immunohistochemical study of estrogen and progesterone receptors in different size classes of ovarian follicles in dromedary camels. Assiut Veterinary Medical Journal 58(134), 382–386.

[27] Seddik, M.M., 2023. Teeth follow-up throughout the life of the dromedary: Zootechnical and veterinary importance. Biol. Life Sci. Forum, 22(1): 10.

[28] Skidmore, J.A., 2011. Reproductive physiology in female Old World camelids. Anim. Reprod. Sci., 124(3–4): 148–154.

[29] Skidmore, J.A., Billah, M. and Allen, W.R., 1996. The ovarian follicular wave pattern and induction of ovulation in the mated and non-mated one-humped camel (Camelus dromedarius). J. Reprod. Fertil., 106: 185–192.

[30] Tibary, A., 2019. Monitoring and controlling follicular activity in camelids. Theriogenol., 109: 22–30.