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Ovarian Morphometry and Follicular Population in Non-Pregnant and Pregnant *Camelus dromedaries*

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Abstract

THIS STUDY investigates the influence of ovarian side and pregnancy status on the ovarian morphometry and follicular population in *Camelus dromedaries*. Two groups were studied: the first group included non-pregnant camels, while the second group included pregnant camels. The current study assessed ovarian morphometry (dimensions, weight) and follicular count in the ovaries of both groups. Results showed that the total follicular populations and the average number of small-, medium-, and large-sized follicles were significantly higher ($P > 0.05$, $P > 0.01$, respectively) in the left non-pregnant Camelus dromedary ovaries than those of the right ones. In pregnant camels, both the dimensions and weight of ovaries containing corpus luteum (CL) were significantly greater ($P< 0.01$) than those of ovaries without a CL. The total follicular populations of pregnant ovaries bearing a CL were significantly higher ($P< 0.05$) than those of non-bearings CL. Moreover, the mean number of small and medium follicles in pregnant ovaries bearing a CL was significantly ($P< 0.01$) higher than those of pregnant ovaries non-bearing CL. On the other hand, the mean number of large follicles in pregnant ovaries non-bearing CL was significantly ($P< 0.01$) higher than those of pregnant ovaries bearing a CL. In conclusion, the study highlights that ovarian side influences the total follicular count and size distribution, while the presence of the CL significantly affects ovarian morphometry. These findings provide valuable insights into the reproductive physiology of dromedaries, which are essential for optimizing breeding management strategies in this species.

Keywords: Camel, ovarian side, pregnancy status, morphometry, Follicles.

Introduction

The *dromedary camel* is a vital livestock species in arid and semi-arid regions due to its adaptability to the harsh environment. Humans depend on this animal not just for meat, milk, and hide, but also for sports and show, and as one of the most important modes of transport in the desert [1]. The dromedary camel possesses distinctive reproductive characteristics such as delayed puberty (up to 4 years), seasonality of breeding activity, follicular dynamics, and left horn pregnancy [2]. Understanding the reproductive biology of dromedaries is essential for enhancing fertility management and optimizing breeding programs.

The ovaries are the main reproductive organs that are responsible for the generation of gametes and steroids throughout different phases of the estrous cycle and gestation. The follicle counting method is a highly effective reproductive characteristic for accurately assessing ovarian features [3], [4]. Despite significant advancements in ovarian examination methods, there remain contentious areas that require additional research. There has been limited research on the classification of ovarian types and the visual assessment of follicles, particularly in dromedary camels [5].

The corpus luteum (CL) is a temporary structure in the ovary that is rich with blood vessels. Within a few days, it forms from a corpus hemorrhagicum and

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gradually produces increasing levels of progesterone (P4). Increased blood circulation to an ovary containing a CL [6] enhances hormones, the dispersion of growth factors and nutrients into the adjacent tissue could promote the growth of follicles and the development of oocytes. Furthermore, it suppresses the release of gonadotropins, which are responsible for suppressing behavioral estrous activity [7]. Corpus luteum produces P4, which stops the dominant follicle from growing and counteracts the effect of inhibin, allowing the development of other follicles [8]. [9] found that the presence of CL has a substantial impact on the concentrations of growth factors in the follicular fluid.

Ovarian morphometry refers to the size, shape, and structural characteristics of the ovaries. Studying the female reproductive system's physical structure using biometrics is a valuable technique for understanding several physiological and reproductive phenomena in animals. Very few researchers had dealt with the morphometry of camel ovaries in relation to season [10; 11 and 12]. Previous studies had indicated variations in ovarian activity related to factors such as season [13], age [10], and reproductive status [13; 14 and 15]. However, our understanding of how pregnancy and the ovary side (right vs. left) affect ovarian morphometry and follicular dynamics in dromedaries remains limited. This study aims to fill this gap by systematically analyzing these aspects.

Material and Methods

Sample Collection

We collected pairs of ovarian samples in plastic bags from 50 adult female dromedaries, including 25 pregnant and 25 non-pregnant animals, slaughtered at a local slaughterhouse. The specimen was transported to the laboratory in a thermos flask filled with warm normal saline solution (0.9% NaCl) and antibiotics (Penicillin/Streptomycin) at 37 °C.

Morphometric Analysis

Excessive tissues that were attached to the ovaries were carefully removed in the laboratory, and the ovaries were weighed using a digital balance (0.0000, Radwag, Poland). We measured the ovarian dimensions (length and width) using a Vernier calliper.

Follicular Population Assessment

The number of visible follicles in each ovary was counted, and their diameter was assessed using callipers. The follicles were categorized according to their diameter [13] into different groups: small (<3mm), medium (3 to 9 mm), and large (>10 m) .

Experimental design

The animals were divided according to the status of pregnancy into two groups.

Group 1 (non-pregnant dromedary camels; n = 25).

Group 2 (pregnant dromedary camels; n = 25). The length, width, weight, and follicular population of left and right ovaries of pregnant dromedary camels, either bearing or non-bearing CL were estimated.

Statistical analysis

The data were examined with the software package (SPSS 20). We conducted differences between the left and right ovaries and between pregnant and non-pregnant groups using paired t-tests. We deemed a P-value below 0.05 as statistically significant.

Results

The length, width, and weight of the left non-pregnant ovaries were higher by 5.9%, 4.0%, and 23.5% respectively, compared to the right non-pregnant ovaries (Table 1). These findings indicate differences in length, width, and weight between the right and left ovaries, with the left ovary being slightly larger in both dimensions and weight, though these differences may not be statistically significant.

Total follicular populations were significantly (P< 0.05) higher in the left non-pregnant *Camelus dromedaries* 'ovaries than those of the right non-pregnant ovaries. The total follicular population of the left non-pregnant was significantly (P< 0.05) higher by 30.8% than the right ones. The average numbers of small, medium, and large follicles were significantly (P< 0.01) higher in the left non-pregnant *Camelus dromedaries*'ovaries than those of the right ones. There was a marked (P< 0.01) increase in the numbers of small, medium, and large follicles by 158.7%, 66.1% and 100% respectively, in the left non-pregnant *Camelus dromedaries* compared to the right ones. These differences suggest that the left ovary may have a greater ovarian reserve or follicular activity under the studied conditions. (Table 2). The length, width, and weight of pregnant Camelus dromedaries bearing CL were significantly (P< 0.01) higher than those of pregnant *Camelus dromedaries* non-bearing CL. Dimensions (length, width) and weight of pregnant *Camelus dromedaries* bearing CL were significantly (P< 0.01) increased by 29%, 20.8%, and 147.2%, respectively, compared to the pregnant *Camelus dromedaries* non-bearing CL (Table 3).

Total follicular populations were significantly (P< 0.05) higher in the pregnant Camelus dromedaries non-bearing CL than those of the pregnant *Camelus dromedaries* bearing CL. The total follicular population of the pregnant *Camelus dromedaries* non-bearing CL was significantly higher by 25.1% than those of the pregnant *Camelus dromedaries* bearing CL. The average number of medium follicles was significantly (P< 0.01) higher in the pregnant *Camelus dromedaries* non-bearing CL than those of the pregnant *Camelus dromedaries* bearing CL. There was an increase in the number of small follicles and a marked significant (P< 0.01) increase in the number of medium follicles by 9.8%, and 66.2% respectively, in pregnant *Camelus dromedaries* with non-bearing CL than that of the pregnant *Camelus dromedaries* bearing CL. Moreover, the number of large follicles was higher by 7.1% in the pregnant non-bearing CL *camelus dromedary* ovaries compared to that of the pregnant bearing CL ovary (Table 4).

Discussion

The present investigation was conducted to determine whether the ovarian side and CL influence the morphometrics and the numbers of total follicles of varying sizes: large, medium, and small in camel ovaries. The results of the present study revealed that the weight of the left non-pregnant ovaries was non-significantly (P > 0.05) higher compared to the right ones. Our results partly agree with that reported in camel [11], who found that the ovarian weight was significantly (P< 0.05) higher on the left side ovary in the breeding season than the right one. Also, our results partly agree with those reported in buffalo [16], who found that the weight of the left ovary of cyclic and non-cyclic Kundli buffaloes was significantly higher than that of the right ovary. However, it was contrasted with that reported in ewes [17] who found that the weight of right ovary was non-significantly higher than that of the left ovary. The findings on cattle reported by [18] contradicted our results. They noted that the weight of right ovaries was non-significantly higher compared to the left ovaries. The differences between their findings and our findings may be attributed to the presence of CL mostly in the right-side ovary in cattle, not in the left-side ovary as seen mostly in camels.

Moreover, our results showed that the length of the left non-pregnant *camel dromedaries* was non-significantly higher compared to the right ones (P > 0.05). Our results partly disagree with that reported in cattle [18], who found that the length of the right ovaries was non-significantly greater than that of the left ovaries. Also, our results were contrasted with those reported in buffalo [16] and in ewes [17], who discovered that the length of the right ovaries was significantly greater than that of the left ovaries, with a statistical significance of P < 0.05.

Our results showed that the width of the left side non-pregnant ovary was non-significantly higher than that of the right side one. Our results agree with that reported in camels [11], who found that the width of the left side ovary was non-significantly higher than that of the right side in the breeding and non-breeding seasons with significantly (P< 0.05) higher ovarian width in the breeding season compared to the non-breeding season. Also, our results agree with that reported in cattle [18]. However, our results disagree with those reported in buffalo [16], who found that the width of the right side ovary was non-significantly higher than of the left side. Their study looked at the ovarian activities of cyclic and non-cyclic buffaloes. Also, our results were contrasted with those reported in ewes [17].

These findings are consistent with previous studies, which have often reported slight asymmetry in ovarian dimensions between the two sides [19]. This difference might be attributed to anatomical and vascular variations, as the left ovary often receives blood supply directly from the left ovarian artery, while the right ovary's vascular network connects to the inferior vena cava, potentially affecting its development and dimensions [20].

Total follicular populations were significantly (P< 0.05) higher in the left non-pregnant camel than in the right ones. This finding aligns with previous studies that report functional asymmetry between the ovaries, where the left ovary often exhibits greater follicular activity. Such asymmetry may be influenced by differences in vascularization, hormonal milieu, or local ovarian microenvironment. On the other hand, our results partly disagree with those reported in cattle [18]. In non-pregnant camels, the ovaries exhibit distinct structures such as follicles at different stages of development, CL, and corpora albicana (regressed luteal bodies).

A detailed examination of follicular size distribution further highlights the asymmetry. The left ovary contains a significantly greater number of small follicles compared to the right ovary (P < 0.01). This higher count may suggest that the left ovary has a more robust reserve of primordial or early-stage follicles ready for recruitment [21]. Similarly, medium follicles are more prevalent in the left ovary than in the right (P < 0.01), indicating higher activity in the intermediate stages of follicular development. The left ovary also contains a significantly greater number of large, likely preovulatory follicles compared to the right ovary (P < 0.01). This may reflect a predisposition for ovulatory dominance on the left side. However, our results were contrasted by those reported in cattle [18], who found that the quantity of small and medium follicles in the right ovary showed a significant increase of 0.2, 0.9, and 1.1 times in comparison the left ovary (P < 0.05). We can attribute the differences between their findings and our findings to the higher activity of the left ovaries in *Camelus dromedaries* than that of the right ovaries, as all pregnancies occur in the left uterine horn [22]. Our findings suggest a notable increase in ovarian activity and development in the pregnant bearing CL, potentially due to the hormonal changes associated with pregnancy.

Reproductive diseases have become increasingly significant in recent years. Corpus luteum secretes

P4, which is one of the primary factors contributing to reduced fertility in cows. Corpus luteum in camels had a significant impact on ovarian morphometry parameters, accounting for almost 50% of the ovarian tissue. In our study, the length, width, and weight of the pregnant *Camelus dromedaries* bearing CL ovaries were significantly (P < 0.01) higher than those of the pregnant non-bearing CL. Our findings align with the findings reported in cattle [23]. Moreover, our results partly agree with those reported in cattle [24] and [18], who found that the length and width of ovaries bearing CL were higher in comparison to ovaries non-bearing CL. Furthermore, our results partly agree with those reported in cattle [25] and [26], who found that the ovaries with CL had a considerably greater weight compared to ovaries without CL. Also, our results partly agree with those reported in ewes [17], who found that ovaries with CL exhibited a significant increase in both ovarian weight and width in comparison to ovaries without CL. Pregnant camels showing slight enlargement of the ovaries due to hormonal changes and increased vascularity. Increased vascularity in the ovaries is often observed during pregnancy. This increased blood flow supports the development and maintenance of the pregnancy.

Total follicular populations were significantly (P< 0.05) higher in the pregnant *Camelus dromedaries* non-bearing CL than in the pregnant ones bearing CL. Our results agree with those reported in ewes [17]. Although our results contrasted with those reported in cattle [18], who found that the total follicular population of the ovaries' bearing CL was non-significantly higher than the ovaries non-bearing CL. In pregnant camels, the ovaries show less follicular activity because of pregnancy hormones, particularly progesterone, which suppresses ovulation. The asymmetry in follicular populations reflects the specialized role of the bearing ovary during pregnancy. The dominance of the CL in the bearing ovary prioritizes progesterone production to maintain pregnancy, often at the expense of ongoing follicular maturation. The non-bearing ovary, free from this responsibility, retains a more active follicular pool. These findings are critical for understanding ovarian physiology during pregnancy.

The average number of small follicles was non-significantly higher in pregnant *Camelus dromedaries* non-bearing CL than that of the pregnant *Camelus dromedaries* bearing CL. Our results align with the findings reported in cattle [23]. Moreover, our results agree with those reported in cattle [25], who discovered that ovaries without CL had a greater quantity of follicles ranging from 2 to 6 mm with a significance level of P < 0.05 in comparison to ovaries with CL. However, they selected ovaries randomly irrespective of their reproductive status. On the other hand, our results disagree with those reported in cattle [18], who found that small follicles were significantly higher in bearing CL ovaries than those of the non-bearing CL ovaries. Moreover, our work was contrasted by that reported in Buffalo [27], who found that small follicles in the luteal phase of non-pregnant ovaries were non-significantly higher than those of the follicular phase. Their work concerned non-pregnant ovaries, not pregnant ovaries as in our work.

Our work showed that the average number of medium follicles was significantly (P< 0.01) higher in the pregnant *Camelus dromedaries* with non-bearing CL than those of the pregnant *Camelus dromedaries* bearing CL. Our results align with the findings reported in cattle [23]. Also, our results partly agree with those reported in Buffalo [27], who found that medium follicles in the luteal phase of non-pregnant ovaries were non-significantly higher than that of the follicular phase. On the other hand, our results disagree with those reported in cattle [18], who found that the medium follicles were higher in the bearing CL ovary than those of the non-bearing CL ovary.

Our work revealed that the average number of large follicles was non-significantly higher in the pregnant *Camelus dromedaries* with non-bearing CL than those of the pregnant ones bearing CL. Our results were in accordance with reported in Cattle [23] and partly agree with those reported in Buffalo [27], who showed that the large follicles were significantly higher in the follicular than in the luteal phase. Also, our work partly agrees with that reported in Cattle [25], who found that the ovaries without CL had greater follicles > 6 mm with a significance level of P > 0.05 in comparison to the ovaries with CL. However, it was contrasted with that reported in cattle [18], who found that the number of large follicles was non-significantly higher in the bearing CL ovaries than those of non-bearing CL ones. The reproductive status of animals effect on hormonal profile, antioxidant status, trace elements, blood biochemical, and metabolites [28]. Also, stress may cause apoptosis of certain cell [29].

Our results suggest that while follicular populations in the pregnant-bearing CL may be slightly reduced, the non-bearing CL maintains higher follicular activity, particularly in medium-sized follicles.

In conclusion, the ovarian morphometry and follicular population in *Camelus dromedaries* are associated with the reproductive status of the animal. In non-pregnant camels, there is active follicular development, while in pregnant camels, ovarian activity is suppressed to maintain pregnancy. Understanding these dynamics is essential for improving camel breeding practices, particularly for managing fertility and reproduction in this species.

Further research is warranted to explore the clinical relevance of ovarian asymmetry and how it may influence the reproductive outcomes. It should explore the molecular and genetic factors influencing the ovarian asymmetry.

Conflict of interest

The authors affirm that they do not have any conflict of interest.

Acknowledgment

Not applicable

Ethics approval and consent to participate

The in vivo experimental protocol received approval from the Institutional Animal Care and Use Committee of the National Research Centre of Egypt (Approval no: 13050416-3).

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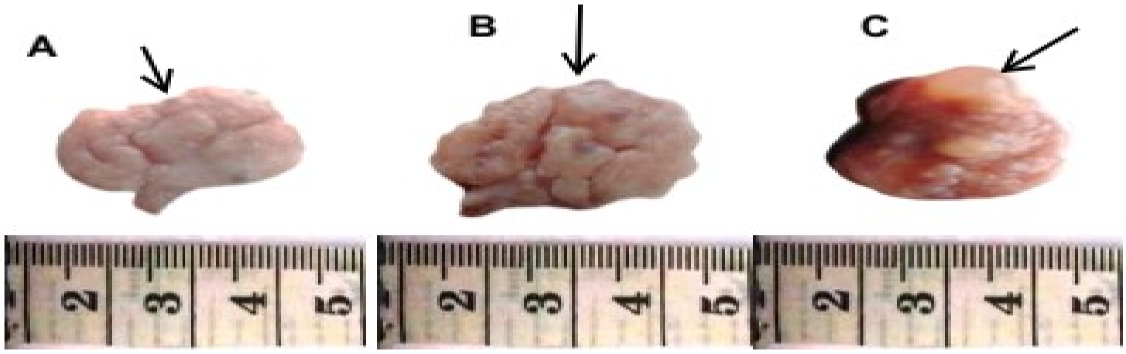

Fig. 1. Camel ovaries showing small follicles(A), medium follicles (B), large follicles (C).

TABLE 1. Ovarian dimensions of left and right non-pregnant *Camelus dromedaries* (mean ± SE).

Ovarian parameters	Left non-pregnant ovary	Right non-pregnant ovary
Length (cm)	3.6±0.1	3.4±0.1
Width (cm)	2.6±0.1	2.5±0.1
Weight (gm)	6.3±0.5	5.1±0.4

TABLE 2. The follicular population of left and right non-pregnant *Camelus dromedaries* (mean ± SE)

Follicular populations	Left non-pregnant ovary	Right non-pregnant ovary
Total follicular population	25.5±2.1*	19.5±1.7
Small follicles	11.9±1.2**	4.6±0.4
Medium follicles	10.3±1.0**	6.2±0.8
Large follicles	2.2±0.7**	1.1±0.5

*Values differ significantly within the same row at P <0.05, ** Values differ significantly within the same row at P < 0.01.

TABLE 3. Ovarian dimensions of pregnant *Camelus dromedaries* bearing and non-bearing CL (mean ± SE).

Ovarian parameters	Pregnant bearing CL	Pregnant non-bearing CL
Length (cm)	4±0.1**	3.1±0.1
Width (cm)	2.9±0.1**	2.4±0.0
Weight (gm)	8.9±0.1**	3.6±0.1

** Values within the same row differ significantly at P < 0.01.

TABLE 4. The follicular population of pregnant *Camelus dromedaries* bearing and non-bearing CL (Mean ± SE)

Follicular populations	Pregnant bearing CL	Pregnant non-bearing CL
Total follicular population	20.7±1.5	25.9±1.3*
Small follicles	11.2±0.8	12.3±0.8
Medium follicles	6.5±0.5	10.8±0.7**
Large follicles	1.4±0.3	1.5±0.3

*Values differ significantly within the same row at P < 0.05, ** Values within the same row differ significantly at P < 0.01.

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قياسات المبيض الشكلية وعدد الجريبات فى النوق العشار وغير العشار

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قسم التكاثر فى الحيوان والتلقيح الصناعى، معهد البحوث البيطرية، المركز القومى للبحوث، الدقى12622، الجيزة، مصر.

الملخص

تستقصى هذه الدراسة تأثير جهة المبيض وحالة العشار على القياسات الشكلية المبيضية وتعداد الجريبات فى النوق.تم دراسة مجموعتين : المجموعة الأولى تشمل الجمال غير العشاروالمجموعة الثانية تشمل الجمال العشار.قيمت الدراسة الحالية قياسات المبيض الشكلية (الأبعاد والوزن) وعدد الجريبات فى مبايض كل المجموعات. أظهرت النتائج ان عدد الجريبات الكلى ومتوسط عدد الجريبات الصغيرة والمتوسطة والكبيرة كانا اعلى معنويا (أ< 0.05 وأ< 0.01على الترتيب) فى المبيض جهة اليسارفى النوق غيرالعشارعن تلك جهة اليمين. فى الجمال العشار كل من الأبعاد والوزن فى المبايض التى تحتوى على الجسم اكبر معنويا (أ< 0.01) عن المبايض التى بدون الجسم الأصفر. كان عدد الجريبات الكلى فى مبايض النوق العشار الحاملة للجسم الأصفر أعلى معنويا (أ< 0.05) عن تلك التى لا تحمل الجسم الأصفر. علاوة على ذلك كان متوسط عدد الجريبات الصغيرة والمتوسطة فى مبايض العشار الحاملة للجسم الأصفر أعلى معنويا (أ< 0.01) عنها فى مبايض العشار غير الحاملة للجسم الأصفر. على الجانب الأخر كان متوسط عدد الجريبات الكبيرة فى مبايض العشارغيرالحاملة أعلى معنويا (أ< 0.01) عن مبايض العشار الحاملة للجسم الأصفر. ختاما تسلط الدراسة الضوء على أن جهة المبيض تؤثر على تعداد الجريبات الكلى والتوزيع الحجمى بينما يؤثر وجود الجسم الأصفرعلىالقياسات الشكلية المبيضية . توفر هذه النتائج رؤى قيمة في فسيولوجيا التكاثر عند الإبل، والتي تعد ضرورية لتحسين استراتيجيات إدارة التربية في هذا النوع.

الكلمات الدالة: الجمال، جهة المبيض، حالة الحمل، القياسات الشكلية، الجريبات.