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# Influence of L-carnitine on Ovarian Activity, Hormonal Profile and Fertility in Barki Ewes under Semi-Aired Conditions

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**Abstract**

TO EVALUATE the impact of L-carnitine (LC) on ovarian follicular activity, fertility, and biochemical parameters in Barki ewes under semi-aired conditions, thirty Barki ewes were divided into three groups (10 animals each). The first group functioned as the control group. The second group (T1) received 500 mg LC/ head/ week. The third group (T2) received 1000 mg LC/ head/ week for 9 weeks. The results showed that Pregnancy and fertility rates and prolificacy recorded higher ($P<0.05$) values in T1 than in control and T2 groups. LC injection efficiently reduced the mortality rate ($P<0.05$) in comparison to the control group. These findings were supported by blood biochemical and hormonal analysis results as LC-supplemented groups yielded a reduction in serum total cholesterol (TC) and T4 ($P<0.05$) concentrations when compared to the control group, while, serum concentrations of total protein (TP), albumen (ALB), and T3 were increased ($P<0.05$) in LC-treatment groups relative to those in the untreated group. Serum progesterone (P4) levels in groups treated with LC were greater ($P<0.05$) than in the untreated group. Additionally, minor variations were found in follicular diameter and values between the groups. Thus, L-carnitine can be utilized successfully to enhance the induction of Barki ewes' ovulation and early pregnancy success.

**Keywords:** L-carnitine, Ovarian follicles, Reproductive performance, Barki ewes.

## Introduction

In the animal production sector, sheep play a vital role, especially in arid regions. The primary goal in Egypt has been to increase the reproductive rate in order to increase the output of meat, milk, skin, and soil organic fertilizer obtained from native sheep breeds [1]. Reproductive efficiency is the most essential component influencing the success of most commercial sheep operations; Nevertheless, it remains to be among many challenging aspects to enhance [2]. The majority of prenatal loss occurs before day 18 of gestation, so, preliminary embryonic development might have an importance in changing losses during pregnancy [3]. According to reports, 30% of fertilized oocytes in ovine fail to produce viable offspring, leading to common, but not recognized as a kind of loss in herd productivity [4, 5]. A number of investigations have suggested that the majority of embryonic mortality happens approximately at the period of pregnancy recognition in ewe [6]. Pregnancy miscarriage in ewes was additionally associated with irregular circulatory levels of progesterone, estrogen, and vascular endothelial growth factor [5]. One of the main reasons for the fall in fertility is poor oocyte quality. To date, numerous foods and pharmaceuticals, including various hormones, proteins, growth factors, and antioxidants, have been reported to improve oocyte quality and lessen reproductive disorders [7]. Meanwhile, negative impacts and incidents were observed in different systems [8]. Regarding this issue, numerous research investigations were carried out in vivo or in vitro to identify supplements that might improve oocyte quality and ameliorate infertility issues [9].

L-carnitine (LC; C7H15NO3) is a tiny water-soluble molecule that is essential for fat metabolism. Additionally, it is vital for appropriate fatty acid oxidation in the mitochondria and the generation of Acyl-CoA esters [10]. Moreover, L- carnitine neutralizes free radicals, eliminates superoxide anions, and prevents lipid peroxidation, hence suppressing hydrogen peroxide damage [11]. L-carnitine is believed to have a positive influence on improving

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ovarian function and the conception rate [12]. the main objective of the present study was to investigate the effect of varying amounts of L-carnitine on ovarian activity and several biochemical parameters in Barki ewes under semi-aerated settings.

## Material and Methods

The research study was conducted at Mariout Research Station (Latitude 31◦ 00' N; Longitude 29◦ 47' E), which falls under the Desert Research Center, Ministry of Agriculture and Land Reclamation, Alexandria, Egypt. All animals were housed in semi-open corrals during the course of the study (October – December 2022).

*Animal management*

Thirty healthy and fertile Barki ewes, aged between 2-3 years and weighted 38 ± 0.23 kg were utilized for the study. The animals were provided a concentrated combination of feed based on the body weight requirement [13] with free access to fresh water. The chemical compositions of feedstuffs are presented in Table 1.

*Experimental design*

The ewes were allocated evenly as three groups: The first was as a control. The second group (T1) received 500 mg/ head/ week LC (Arab company for pharmaceuticals and medicinal plants, Egypt). The third group (T2) received 1000 mg/ head/ week of LC. L-carnitine was injected weekly into the jugular vein for nine weeks (4 weeks before estrus synchronization and 5 weeks after estrus synchronization).

*Estrus synchronization*

Estrous synchronization was practiced in each ewe using double injection protocol (1 mL, im.) of prostaglandin PGF2α (Estrumate, 263 µg Cloprostenol/mL, Schering-Plough Animal Health, Germany) 9 days apart [14].

*Blood samples*

Samples were obtained from all animals using serum vacutainers (without anticoagulant) at 0, 1, 2, 3, 4, and 5 weeks of LC injection, and continued to be collected biweekly at 7 and 9 weeks during the natural mating season. Also, the collection of blood samples was conducted at times -7, 0, and 3 after the 2nd PGF2α dose in order to estimate the changes in serum estradiol 17- β (E2). Additionally, the changes in serum progesterone (P4) were determined at times (-7, 0, 11, 18, and 33). The blood specimens were spun in a centrifuge at 3000 rotations per minute (rpm) for 20 min., followed by serum extraction and storage at -20°C until analysis.

*Analysis of hormones and serum biochemicals*

The commercial ELISA kits (DiaMetra and ZEUS diagnostic, USA) were applied to analyze the serum estradiol 17- β (E2) and progesterone (P4) concentrations according to [15, 16] respectively. Serum thyroid hormones including (triiodothyronine, T3, and thyroxine, T4) were analyzed applying commercial ELISA kits (ZEUS diagnostic, USA) as stated by [17]. Concentrations of total glucose (Glu), total cholesterol (TC), total proteins (TP), and albumin (ALB) were determined using colorimetric kits (Diamond Diagnostics, Egypt) according to [18-21].

*Ultrasound examination and mating*

The ovaries have been examined with an ultrasound scanner (100 SL; Pie Medical, the Netherlands) integrated with 5.0–7.5 MHz dual frequency linear transducer was used for transrectal ultrasonography. The ovarian follicles were counted and their diameters were recorded. Preovulatory scans were taken at 0 and 3 days (as shown in Figure 1) after the second dose of PGF2α. The follicles were measured and categorized based on their diameter, as follows: small (less than or equal to 3 mm), medium (>3 to <5 mm), and large (≥ 5 mm) [22]. The ewes were naturally mated using 4 mature fertile Barki rams and reproductive traits including pregnancy, fertility, prolificacy, lambing, and mortality rates were recorded.

*Statistical analysis*

All data were collected and analyzed using SPSS statistical package version 22 (IBM Corp., Armonk, NY, USA). One-way analysis of variance (ANOVA) was conducted followed by Tukey's test. The results are expressed as means ± standard error and the p-value was considered significant for values < 0.05.

## Results

*Blood biochemical analysis and hormonal levels*

Data presented in Table 2 and Figure 2 showed the results of blood biochemical analysis and hormonal levels in ewes affected by LC injection.

*Serum glucose (GLU) and total cholesterol (TC) concentrations*

Firstly, serum glucose (GLU) levels were not affected ($P<0.05$) by treatment, time, and treatment_x_time interaction between the experimental groups. The values of GLU were 73.30±2.28, 68.20±2.28, and 70.03±2.28 mg/dL in the control, T1, and T2 groups, respectively. Additionally, the data indicated that TC concentrations were affected ($P<0.05$) by LC treatment and time. However, no interactions were detected between treatment and time. The Overall means of TC concentrations decreased ($P<0.05$) in T1 and T2 (73.40 and 69.43±0.817 mg/dL, respectively) compared to those in control ewes (76.06±0.817 mg/dL).

*Serum total protein (TP) and albumin (ALB) concentrations*

In the current study, serum concentrations of TP and ALB were affected (P<0.05) by treatment and by time but not affected (P≥0.05) by treatment_x_time interaction between the examined groups. The T2 group achieved the highest (P<0.05) overall mean of serum TP and ALB (7.54± 0.167 and 5.76±0.151 g/dL, respectively) followed by the T1 group (7.25±0.167 and 5.67±0.151 g/dL, in order) in comparison with the control group (6.63±0.167 and 5.19±0.151 g/dL, respectively).

*Thyroid hormones ($T_3$ and $T_4$)*

Our results revealed that serum levels of T3 and T4 were influenced (P<0.05) by the LC treatment but not affected (P≥0.05) by time and by treatment x time between the experimental groups. Overall means of T3 increased (P<0.05) in the T1 and T2 groups (1.25 and 1.39 ±0.126 ng/dL, respectively) in comparison with the control group (0.97 ±0.126 ng/dL). On the other hand, overall means of T4 decreased (P< 0.05) in the T1 and T2 groups (5.24 and 5.26± 0.312 pg/dL, respectively) compared to the control group (6.22± 0.312 pg/dL).

*Serum estradiol 17-β ($E_2$) and progesterone ($P_4$) concentrations*

As shown in Table 2 the serum E2 levels were affected (P<0.05) by time and treatment_x_time in treated groups compared to the untreated group but were not affected (P≥0.05) by treatment. The overall mean of serum E2 concentrations was higher (P≥0.05) in the LC-supplemented groups (T2 and T3) than in the control group (24.51±1.57, 23.75±1.57, and 21.24±1.57, pg/ml, respectively). The LC groups achieved the highest values of E2 recorded on day 3 of the second PGF2α injection (Estrous-stages) with values being 41.35± 11.52 and 35.7± 13.27 pg/ml, for T2 and T1 groups, respectively, in comparison with the control group (28.33 ±0.45 pg/ml) as shown in Figure 3. In addition, there were no differences (P<0.05) among groups in the serum E2 concentrations regarding days -7 and 0 of the second PGF2α injection.

Also, serum concentrations of P4 were affected (P<0.05) by treatment, time, and treatment_x_time between the experimental groups (as previously shown in Table 2). In addition, the overall means of serum progesterone (P4) of L-carnitine treated groups (T1 and T2) were higher (P<0.05) than that of the untreated group (2.59±0.08 and 2.77±0.08, and 1.94±0.08 ng/mL, respectively). The analysis of P4 concentrations on days 3, 18, and 33 after the second PGF2α dose presented a substantial increase in treated ewes in contrast to the unaltered group as presented in Figure 4. Moreover, serum P4 concentration exhibited no changes (P<0.05) among groups on days -7 and 0 of the second dose of PGF2α injection.

*Follicular number and diameter (mm)*

The obtained results demonstrated that L-carnitine supplementation did not affect follicular diameter. The overall means of follicular diameter (mm) were 4.61±0.32 and, 4.36±0.32 mm in T1 and T2, respectively, and 4.60±0.32 mm in the control group. Moreover, time didn't reveal any effects (P<0.05) on follicular diameter (Figure 5). Overall means of largest follicles were (P<0.05) recorded in the T1 group (6.28±0.87mm) followed by the T2 group (5.91±0.87mm) then the control (5.75±0.87mm). However, the overall means of small and medium follicles showed no differences (P<0.05) among all groups (Figure 6). On the other hand, LC-supplemented groups had higher (P<0.05) overall means of follicular number (T1, 3.9±0.48 and T2, 2.8±0.48mm, respectively) in comparison with the control group (2.6±0.48, mm). However, time did not affect follicular number (Figure 7).

*Reproductive performance*

The data in Table 3 indicated that dietary supplementation with L-carnitine improved the reproductive performance indicators in Barki ewes. Pregnancy and fertility rates and prolificacy recorded higher (P < 0.05) values in the T1 group being 100 % each, followed by the control group (80, 80, and 100%, respectively), then the T2 group (70, 60, and 85.71 %, respectively). The findings of the current work demonstrated that embryonic loss was higher (P<0.05) in the T2 group than control and T1 groups (14.28 %, 0, and 0, respectively). Furthermore, the mortality rate was reduced (P<0.05) in both LC-treated groups compared to the control group (0, 0, and 25%, respectively).

## Discussion

The findings of the current study indicated that the low dose (500 mg/head/week for nine weeks) of L-carnitine administration at the beginning of the breeding process, improved the reproductive performance of Barki ewes under the semi-aired conditions. This finding was supported by the blood biochemical and hormonal analysis during the study. According to the current research, there were minor variations in serum glucose values between the groups. In agreement with our findings, previous studies [23, 24] observed that L-carnitine supplementation had no noticeable effect on the levels of glucose. Additional studies, otherwise, revealed that oral administration of L-carnitine increased plasma glucose levels in cows, growing sheep, goats, and chicks [25- 28]. Furthermore, in the current study, the interaction between L-carnitine treatment and time did not significantly affect the glucose levels. L-carnitine administration may influence glucose metabolism by enhancing glucose absorption, storage, and oxidation [29].

Since energy production must support up to 21 cell number doublings during a follicle's development, some species have a high metabolic

requirement. Similarly, high amounts of cellular energy in the form of Adenosine triphosphate (ATP) are linked to high levels of oocyte quality [30]. Lipids are a potent source of ATP and several folds more energy-rich than glucose. Attention has been focused on the developmental significance of lipid metabolism during the acquisition of oocyte developmental competence due to the energy-dense nature of lipids and their capacity to generate substantial ATP from relatively low quantities of external or stored lipid substrate. By β-oxidizing fatty acids, which is mediated by the enzyme carnitine palmitoyl transferase I and requires carnitine, ATP is produced from lipids inside the mitochondria. This has shown that β-oxidation is crucial for follicular growth and that L-carnitine's stimulation of this metabolic pathway is beneficial for development [31]. In addition, the current investigation showed that L-carnitine injection had a substantial effect on total cholesterol concentrations ($P<0.05$). The TC concentrations declined significantly in LC-treated groups compared to control ewes. In agreement, a large number of studies indicated that LC supplementation exhibited a significant reduction in TC concentrations [23, 32-35]. The primary mechanism by which LC supplementation decreased serum total cholesterol was a reduction in cholesteryl esters, instead of a reduction in unbound cholesterol [36]. Furthermore, it may be associated with a rise in the conversion of cholesterol to bile acids or release of biliary sterols [37]. Carnitine accelerates the oxidation of lipids via delivering long-chain fatty acids to be oxidized in the mitochondria [38-41]. In advance of oxidation, fatty acids must be transformed into acyl CoA for energy production. Carnitine aids in the transport of acyl CoA through the mitochondrial wall because it cannot cross cell membranes. As a result, In the absence of carnitine, most dietary lipids cannot be metabolized for energy, resulting in the accumulation of fatty acids and contributing to obesity and hyperlipidemia [42], which could negatively affect ewes' fertility [43].

In the current study, L-carnitine supplementation resulted in significant alterations in serum TP and ALB levels. The T2 group achieved the highest significant overall mean of serum TP and ALB followed by the T1 group in comparison with the control group. Meanwhile, TP and ALB levels were insignificantly influenced by time during the experimental period. In agreement, several studies [32, 34, 44, 45, 46] reported that LC treatment significantly increased the TP concentration. The increment in TP may refer to the increase in protein synthesis resulting from increased anabolic hormones secretion which is accountable for the amino acids consumption [47]. Moreover, several studies [47-50, 34] observed an increase of serum ALB in ewes and does that were treated with L-carnitine. Normal albumin in the bloodstream is important for many physiological functions and it indicates standard state of liver function given that the liver is the primary source of the albumin generation [51]. The increase of albumin in response to L-carnitine administration may be associated with nitrogen absorption [52]. Particularly in small ruminants, plasma albumin serves as a reliable predictor of nitrogen levels [53, 54]. In addition, albumin serves as an important transportable protein source for amino acids [50]. However, the present results disagreed with those reported by other studies [55-57] which found that L-carnitine administration did not affect serum TP and ALB levels. Several variables, such as feed composition, fat or protein levels [58], methionine and lysine contents [59, 60], and vitamin C levels [61], could influence the impact of L-carnitine administration on protein.

Thyroid hormones have an essential role in regulating oxidative metabolism; as a result, any significant functional modifications are reflected as a changed metabolic rate [62]. The present results revealed that T3 concentration increased significantly in LC-treated groups in comparison with the control group. On the other hand, the concentration of T4 significantly reduced in the T1 and T2 groups in comparison with the untreated group. Serum T3 and T4 levels were insignificantly affected by time during the experimental period. However, Mehrez et al., [33] found that LC administration did not affect T3 and T4 levels in growing Rahmani lambs. Moreover, Benvenga et al., [63] observed no changes in thyroid hormone concentration in hyperthyroidism patients treated with LC. It has been established that LC has virtually no impact on serum thyroid hormone levels or their production [64]. The LC reduces cellular internalization of T3 and T4, but not their receptor binding ability, and hence antagonizes thyroid hormone peripheral action [65, 66]. The capacity of LC to suppress both cell entry and nuclear entry of thyroid hormones in human tissue culture supports this idea [67].

Serum estradiol 17-β concentrations were insignificantly higher in LC-supplemented groups than in the control ewes. Serum E2 concentrations in control and LC-supplemented ewes were significantly affected by time during the experimental period. The LC groups achieved the highest values of E2 recorded on day 3 of the second PGF2α injection (Estrous-stages) for the T2 and T1 groups in comparison with the control group. There were no substantial differences between groups in serum E2 concentrations on -7 and 0 days of the second PGF2α injection. The LC was found to increase the release of gonadotropin releasing hormone (GnRH) from the hypothalamus by acting on the hypothalamic-pituitary-gonadal axis (HPG) [68] and leading to K+-induced depolarization in hypothalamic neuronal cells to enhance its secretion function [69] which elevates the concentrations of

reproductive hormones, namely estradiol, progesterone, and luteinizing hormone (LH) in the normal pattern with distinct phases of estrous in animals [68, 70, 71].

On the opposing side, serum progesterone (P4) levels of LC-treated groups were substantially greater than those of the untreated group. In addition, P4 concentrations were significantly affected by time during the experimental period. Analysis of P4 concentrations on days 3, 18, and 33 after the second PGF2α dose showed significant increscent in treated ewes in comparison with the control group. Serum P4 concentration exhibited no significant changes among groups on days -7 and 0 of the second dose of PGF2α injection. Furthermore, Genazzani et al., [72] stated that LC treatment exhibited no alterations in the concentration of reproductive hormones. In contrast with our findings, Elshahat and Aboelmaaty, [73] reported that nutritional treatment with L-carnitine effectively raised serum progesterone levels in Rahmani ewes and enhanced ovulation rate. Regarding its capacity to develop the necessary conditions for hormone synthesis and release via the HPG axis, or potentially by a direct impact on the ovarian tissues, causing the synthesis and release of the steroid hormone.

The L-carnitine treated group recorded a significant increment in serum reproductive hormones level [74], also LC is utilized by the tissues via the electrogenic force of the voltage-gated Na+ channels. This relies on the Na+-driven LC/organic cation transporter to transport into the oocytes [12]. This increases energy generation through β oxidation, reduces stress by removing excessive palmitate, free radicals scavenging to lessen the oxidative stress, and inhibits the caspases in order to prevent apoptosis. Additionally, LC improves hormonal balance and inhibits the secretion of cytokines and apoptosis [68]. Regarding the increase of progesterone concentration on day 33 after mating, it is attributed to placental secretion of P4, which is considered the major source of P4 [75].

The obtained results demonstrated that LC supplementation had no effects on follicular diameter. Moreover, time didn't reveal any significant effects on follicular diameter. The significant largest diameter of follicles was found in the T1 group, then came the T2 group, and the untreated group. However, overall means of small and medium follicles did not show any significant differences among the experimental groups. On the other hand, LC-supplemented groups had higher significant overall means of follicular number in comparison with the control. However, time did not affect follicular number. The results demonstrated that LC at a low dose was sufficient to provide beneficial effects on follicular parameters. In this context, it has been observed that dietary supplementation with LC effectively enhanced the preovulatory follicles size and number on the ovarian surface as well as blood progesterone levels when compared to the control group in Rahmani ewes, thus enhancing ovulation rate [73]. As follicular growth through folliculogenesis is surely done by follicle-stimulating hormone and luteinizing hormone, Fakhrildin and Flayyih [70], suggested that LC possibly work on the HPG axis causing gonadotropic hormonal production, consequently stimulate the development and maturation of graafian follicles.

Dietary supplementation of L-carnitine improved reproductive performance indicators in Barki ewes. Pregnancy and fertility rates and prolificacy recorded significantly higher values in the T1 group followed by the control group, then the T2 group. Results of the present study demonstrated that embryonic loss was considerably greater in the T2 group compared to the untreated control and T1 groups. Furthermore, the mortality rate was substantially reduced by L-carnitine treatment in the T1 and T2 groups compared to the untreated group. These results concur with earlier reports in different animal species, in camels, sheep, and dairy cows [73, 76, 77].

The results indicated that LC at low dose provided beneficial effects on follicular parameters and pregnancy rate. In context with the favorable LC outcomes, Ismail et al., [78] demonstrated that the clinical pregnancy rate among the LC group was much higher than placebo which might indicate that LC promotes early pregnancy success in addition to enhancing the outcomes of ovulation induction and conception. In disagreement, it was reported [79-81] that administration of L-carnitine did not influence the survival and cleavage rates of bovine oocytes during in vitro maturation. The differences between these studies could be explained by the variations in L-carnitine concentrations, timing of L-carnitine dosage, and the presence or absence of certain supplements.

Furthermore, L-carnitine's beneficial role in early pregnancy success could be attributed to the increase in endometrial receptivity and thickness [82-84]. Furthermore, the addition of LC improves ovulation and conception by influencing three critical oocyte functions: it reduces oxidative stress and lipotoxicity by scavenging free radicals and eliminating excess palmitate, it enhances energy generation by moving palmitate into mitochondria while sustaining the acetyl CoA/CoA ratio, and it fosters oocyte growth and maturation by slowing the rate of apoptosis. [85, 86].

## Conclusion

From the findings of this investigation, it can be indicated that the L-carnitine can be utilized in a progressive way to enhance Barki ewes' ovulation induction and early pregnancy success rates. Additionally, the low amount of LC (500

mg/head/week for nine weeks) was enough to produce beneficial impacts on sheep's ovulation and pregnancy rates.

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*Author contributions*

Noura Essa contributed to the conceptualization, laboratory work, statistical analysis, and writing of the manuscript. Ibrahim Abd El-Hamid contributed to the ultrasound examination, laboratory work, and review and editing of the manuscript. Ibrahim Abd El-Hamid, Ahmed Kamel, Bahaa Farrag, and Mohamed Naser contributed to fieldwork and sample collection. The final manuscript was reviewed and approved by all authors.

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*Declaration of Conflict of Interest*

The authors declare that there is no conflict of interest.

*Ethical of approval*

The techniques utilized to gather samples and care for the animals in this experiment were authorized by the Ethics Committee of the Desert Research Centre (DRC), Egypt., which is compatible with the local Experimental Animal Care Committee and according to ARRIVE guidelines.

**TABLE 1. Chemical composition (%) of experimental feedstuffs (as % on DM basis).**

| Ingredient | DM | OM | CP | EE | CF | NFE | Ash |
|---|---|---|---|---|---|---|---|
| **Berseem hay** | 85.1 | 86.85 | 12.09 | 1.36 | 27.57 | 45.83 | 13.15 |
| **Concentrate-feed mixture** | 91.42 | 88.61 | 15.61 | 3.01 | 16.33 | 53.66 | 11.39 |

DM: dry matter, OM: organic matter, CP: crude protein, EE: ether extract: CF: crude fiber, NFE: nitrogen-free extract.

**Table 2. Changes of some blood biochemical and hormonal analysis in Barki ewes treated with LC administration**

| Parameter | Group | Mean ± SE | $P_{Treatment}$ | $P_{Time}$ | $P_{Treatment\ x\ Time}$ |
|---|---|---|---|---|---|
| **GLU (mg/dL)** | **Control** | 73.30±2.28 | 0.082 | 0.672 | 0.938 |
| | **T1** | 68.20±2.28 | | | |
| | **T2** | 70.03±2.28 | | | |
| **TC (mg/dL)** | **Control** | 76.06±0.81 | 0.000 | 0.003 | 0.983 |
| | **T1** | 73.40±0.81 | | | |
| | **T2** | 69.43±0.81 | | | |
| **TP (g/dL)** | **Control** | 6.63±0.16 | 0.000 | 0.026 | 0.661 |
| | **T1** | 7.25±0.16 | | | |
| | **T2** | 7.54±0.16 | | | |
| **ALB (g/dL)** | **Control** | 5.19±0.15 | 0.001 | 0.001 | 0.397 |
| | **T1** | 5.67±0.15 | | | |
| | **T2** | 5.76±0.15 | | | |
| **$T_3$ (ng/ml)** | **Control** | 0.97±0.12 | 0.007 | 0.976 | 0.824 |
| | **T1** | 1.25±0.12 | | | |
| | **T2** | 1.39±0.12 | | | |
| **$T_4$ (µg/dL)** | **Control** | 6.22±0.31 | 0.003 | 0.994 | 0.861 |
| | **T1** | 5.24±0.31 | | | |
| | **T2** | 5.26±0.31 | | | |
| **$E_2$ (pg/ mL)** | **Control** | 21.24±1.57 | 0.374 | 0.000 | 0.000 |
| | **T1** | 24.51±1.57 | | | |
| | **T2** | 23.75±1.57 | | | |
| **$P_4$ (ng/mL)** | **Control** | 1.94±0.08 | 0.000 | 0.000 | 0.000 |
| | **T1** | 2.59±0.08 | | | |
| | **T2** | 2.77±0.08 | | | |

Data presented as overall Means ±standard error of the mean (SE) and *P* value for parameters; glucose (GLU), total cholesterol (TC), total protein (TP), albumen (ALB), thyroid hormones (T3: triiodothyronine, and $T_4$: thyroxine), Estrogen ($E_2$) and progesterone ($P_4$) concentrations in the control and L-carnitine treated groups (T1 and T2).

**TABLE 3. Reproductive performance of Barki ewes affected by L-carnitine supplementation during the experimental period**

| Items | Control | T1 | T2 |
|---|---|---|---|
| **Number of ewes** | 10 | 10 | 10 |
| **Pregnancy rate (%)** | 80[b] | 100[a] | 70[b] |
| **Number of ewes lambing** | 8 | 10 | 6 |
| **Embryonic loss (%)** | 0 | 0 | 14.28 |
| **Fertility rate (%)** | 80[b] | 100[a] | 60[b] |
| **Prolificacy rate (%)** | 100[a] | 100[a] | 85.71[b] |
| **Mortality rate (%)** | 25[a] | 0[b] | 0[b] |

[a-b] values within the same row with different letters differ (P< 0.05). Fertility rate (%): number of ewes lambed/ total ewes treated x100. Prolificacy rate (%): number of lambs born/number ewes lambed x100. Mortality rate (%): Dead kids' number / Total kids parturated x100.

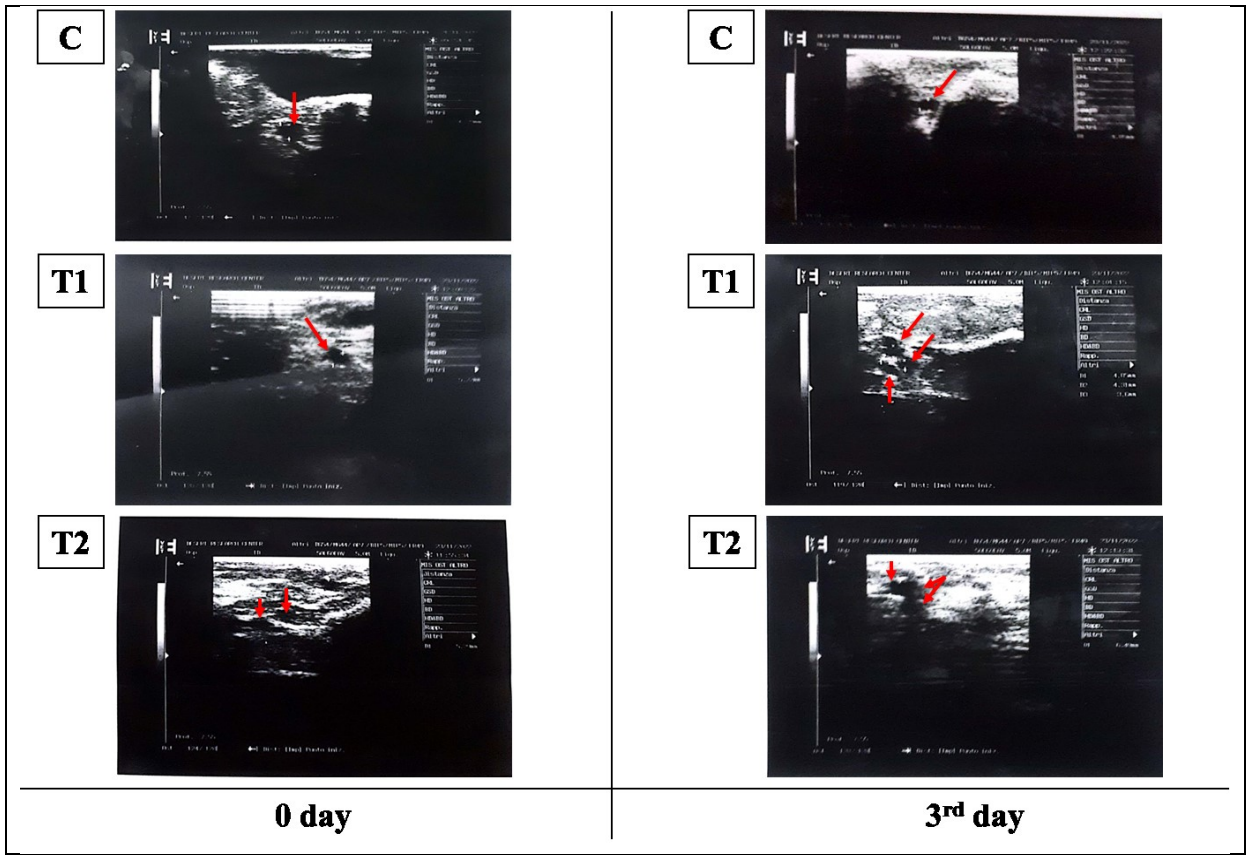


**Fig. 1. Ultrasonography monitoring of ovarian activity in experimental groups before promoting ovulation and mating. C; control group; T1 group received 500 mg/ head/ week of L-carnitine; T2 group received 1000 mg/ head/ week of L-carnitine. 0 day; the day of 2nd $PGF_{2\alpha}$ injection. 3rd day; 3 days after the 2nd $PGF_{2\alpha}$ dose. Red arrows refer to the ovarian follicles.**

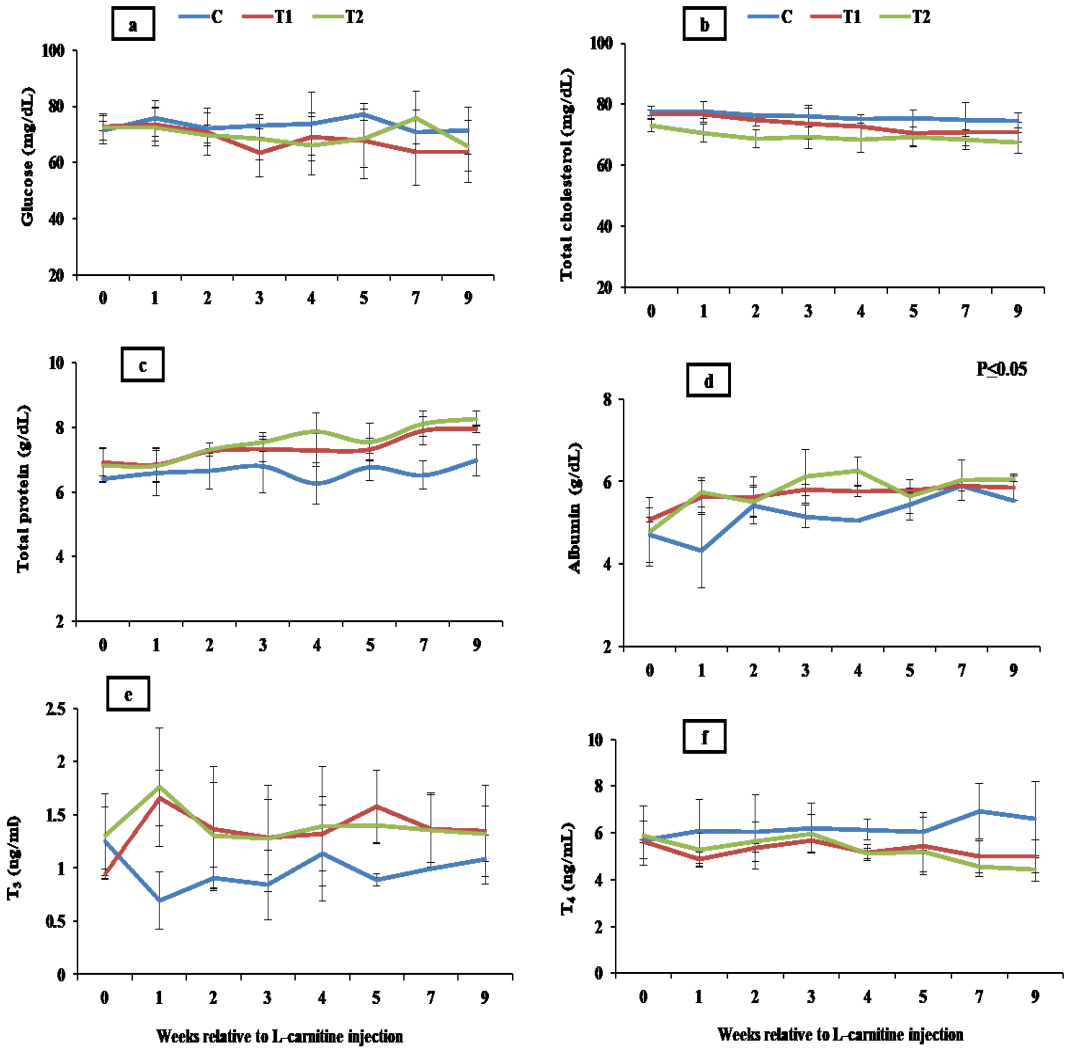


**Fig. 2. Changes in blood biochemicals and thyroid hormones concentrations in Barki ewes treated with L-carnitine, whereas: (a) serum glucose (GLU), (b) total cholesterol (TC), (c) total protein (TP), (d) albumen (ALB), (e) triiodothyronine ($T_3$), (f) thyroxine ($T_4$). The experimental groups are presented as C: the control group, T1: 500 mg group, and T2: 1000 mg group.**

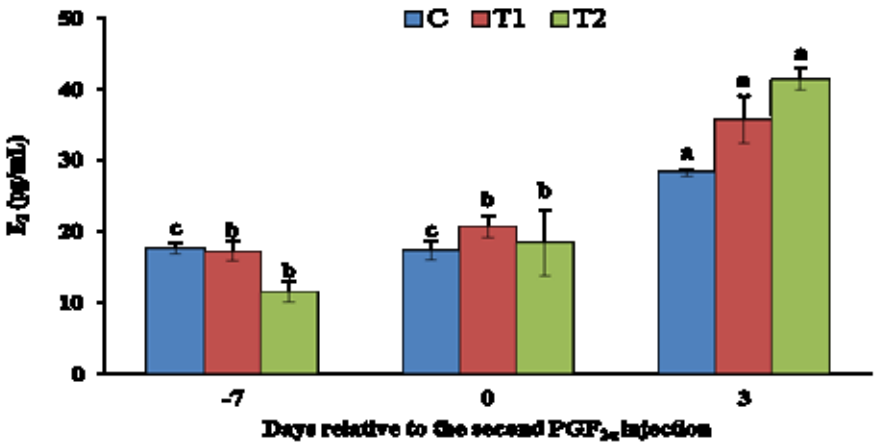


**Fig. 3. Serum estradiol 17-β ($E_2$) concentrations, in the experimental groups relative to the 2"" administration of $PGF_{2\alpha}$, as affected by L-carnitine injection. $^{a-c}$ within each time differs significantly ($p \leq .05$).**

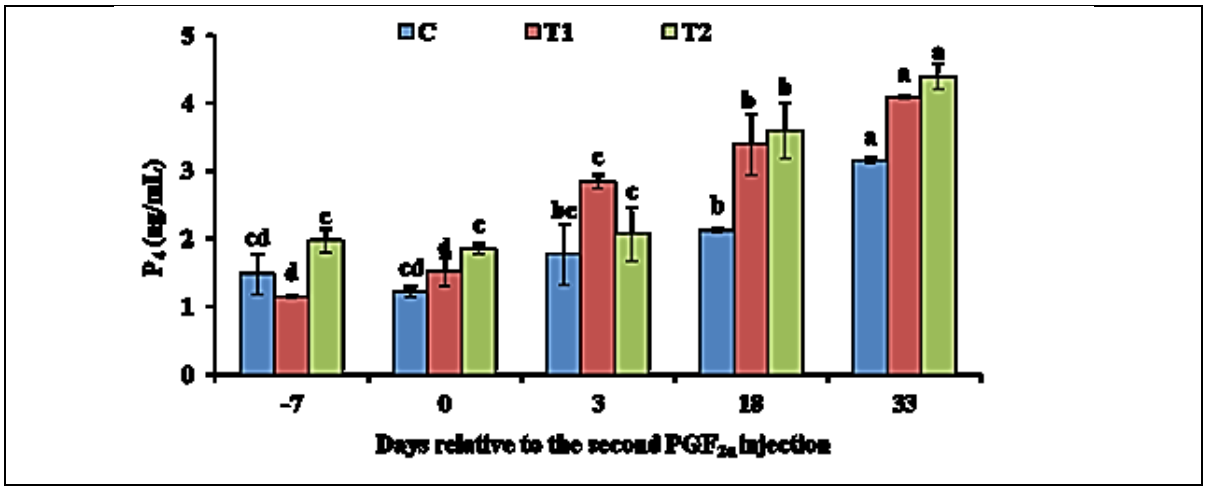


**Fig. 4. Serum progesterone ($P_4$) concentrations relative to the 2nd administration of PGF2α, in the experimental groups, as affected by L-carnitine injection. a-d within each time differ significantly (p ≤ .05).**

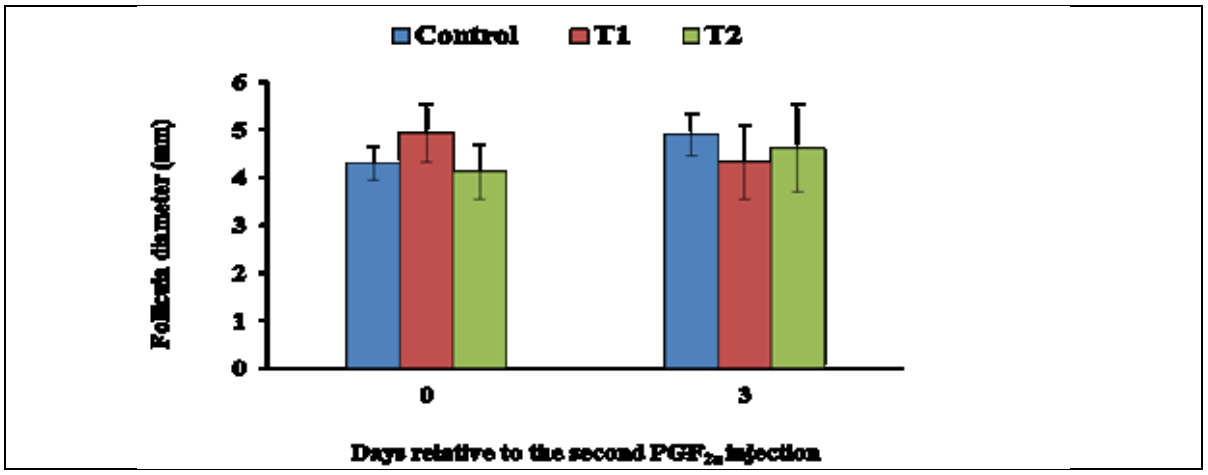


**Fig. 5. Follicular diameter (mm) in Barki ewes treated with LC over 3 days of the 2nd administration of $PGF_{2\alpha}$ (mean ± SEM). Small follicle of Ø< 3mm, medium follicle, follicle measures 3< Ø < 5mm, large follicle, follicle measures of Ø ≥ 5mm.**

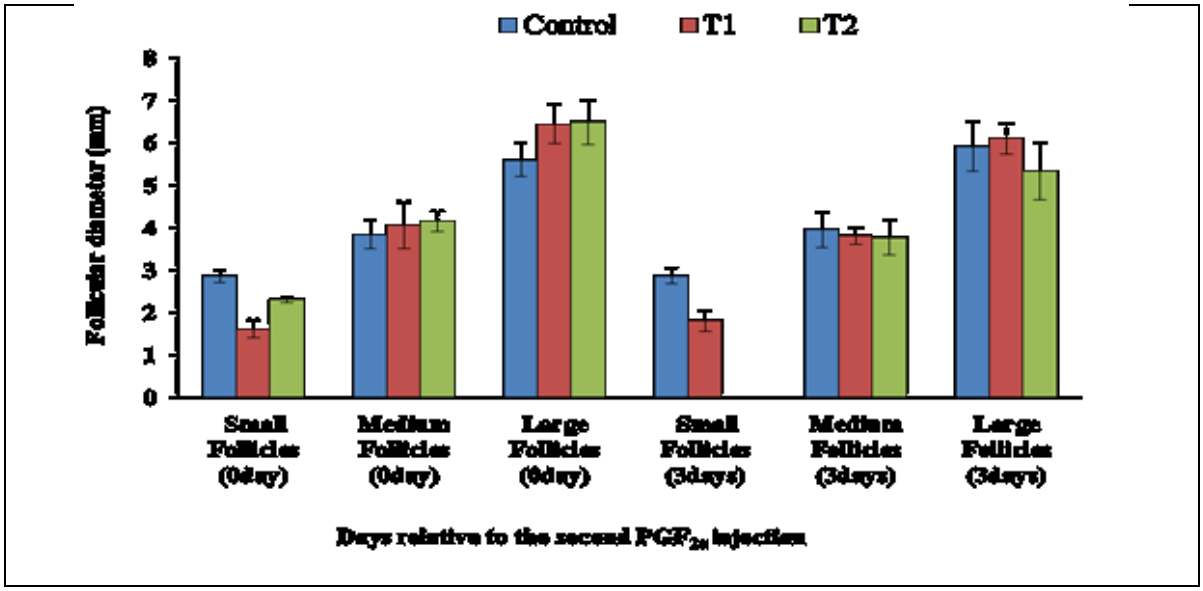


**Fig. 6. Ovarian follicular activity in n Barki ewes treated with LC over 3 days of the 2nd administration of $PGF_{2\alpha}$ (mean ± SEM).**

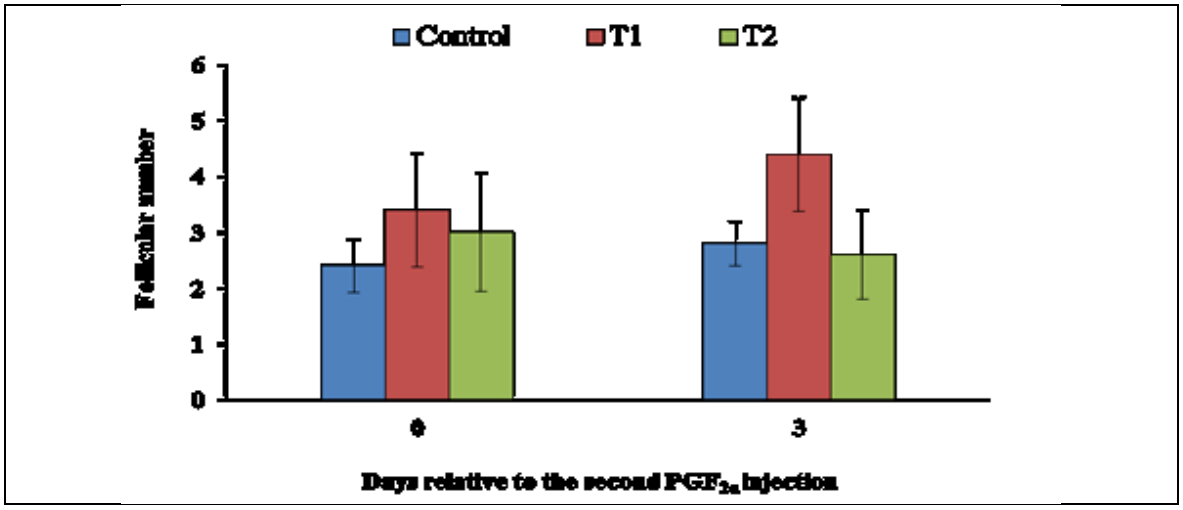


**Fig.7. Follicular number in Barki ewes treated with LC over 3 days of the 2nd administration of $PGF_{2\alpha}$ (mean ± SEM).**

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## تأثير حقن الـ لـ ـ كارنيتين على نشاط المبيض والخصوبة في النعاج البرقي تحت الظروف شبه الجافة

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**الملخص**

الهدف من هذه الدراسة هو دراسة تأثير الكارنيتين L-Carnitine (LC) على نشاط الحويصلات المبيضية والخصوبة وبعض المعايير البيوكيميائية في النعاج البرقي تحت الظروف شبه الجافة. تم تقسيم ثلاثين نعجة برقي بالتساوي إلى ثلاث مجموعات. المجموعة الأولى كانت بمثابة المجموعة الضابطة. المجموعة الثانية (T1) تلقت 500 ملغم من الـ كارنتين/ الرأس/ أسبوع. المجموعة الثالثة (T2) تلقت 1000 ملغم من الـ كارنتين / الرأس/ أسبوع لمدة 9 أسابيع. أظهرت النتائج أن معدلات الحمل والخصوبة سجلت قيماً أعلى ($P<0.05$) في T1 عنها في مجموعتي الضابطة وT2. أدى حقن LC إلى خفض معدل وفيات المواليد بكفاءة ($P <0.05$) مقارنة بمعدل الوفيات في المجموعة الضابطة. تم دعم هذه النتائج من خلال نتائج التحليل البيوكيميائي والهرموني للدم حيث أدت المجموعات المعاملة بـالـ LC إلى انخفاض في تركيزات TC و T4 في المصل ($P <0.05$) عند مقارنتها بالمجموعة الضابطة، في حين زادت تركيزات الـ TP و ALB و T3 بشكل معنوي في المجموعات المعاملة بالـ LC مقارنة بالمجموعة الضابطة. كان مستوى هرمون البروجيستيرون P4 للمجموعات المعاملة بـ LC أعلى ($P <0.05$) من المجموعة الضابطة. بالإضافة إلى ذلك، تم العثور على اختلافات طفيفة في قطر الحويصلات المبيضية والقيم بين المجموعات. وبالتالي نستنتج أنه يمكن استخدام L-carnitine بنجاح لتعزيز تحفيز التبويض عند النعاج البرقي زيادة معدلات الحمل.

**الكلمات الدالة:** الكارنيتين، الحويصلات المبيضية، الأداء التناسلي، النعاج.