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Influence of organic or inorganic forms of salts rich in phosphorus, copper and zinc on reproduction, productivity and blood constituents in sheep

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Abstract

Thirty- nine mature Aboudeleik ewes were fed the basal diet and divided into three groups. The first one was served as control (n=12), the second group received the basal diet plus salts in organic form (2.7 g/h/d DM, n=14) while the third one received (2.7 g/h/d DM, n=13) salts in inorganic form. The supplementation period began one month before mating and continued for waning period. Estrus was synchronized using duple injections of $PGF_{2\alpha}$ prior to the introduction of rams. Serum progesterone profile, blood biochemical constituents and elements concentration were determined during different pregnancy stages. Reproductive performance, productive traits of lambs including birth, weaning weights and average daily gain were also determined. The obtained results declared that the concentration of serum progesterone (P4) was higher (P<0.01) in organic or inorganic-S groups compared with control. Feeding trace element in organic or inorganic salts resulted in a higher (P<0.05) conception rate, while lambing and prolificacy rates increased (P<0.05) in inorganic-S compared with organic-S or control groups. Sex ratio of lambs born from treated ewes was not affected. Furthermore, treatment had no effects on total proteins (TP), albumin (Albu), globulin (Glo), urea concentrations, aspartate aminotransferase (AST) and alanine aminotransferase (ALT). However, lipid metabolites including total lipids (T.L), cholesterol (Cho) and triglycerides (TG) concentrations increased (P<0.05) in treatment groups as compared to control. While serum creatinine (Crea) concentration was higher (P<0.05) in control group than organic or inorganic-S. Serum calcium (Ca), selenium (Se) and iron (Fe) concentrations were not different among treatment groups. While, serum phosphorus (P) and copper (Cu) concentrations increased (P<0.01) in treated groups compared with control. Birth weight for lambs born from ewes supplemented with organic salts was higher (P < 0.05) than those born from ewes supplemented with inorganic-S or control. Weaning weight and average daily gain for lambs of treated ewes increased (P < 0.05) as compared to control ones.

In conclusion, the efficiency of different forms organic and inorganic of salts rich in phosphors, copper and zinc was similar and greatly affected progesterone concentration, lipid metabolism, phosphorus and copper concentrations in serum blood during different pregnancy stages and has a positive effect on the weight of lambs.

Keywords: Aboudeleik, sheep, minerals, pregnancy, trace-elements, serum biochemistry.

INTRODUCTION

Halayeb-Shalateen and Abu Ramad Triangle is located at the border between Egypt and Sudan, on the African coast of the Red Sea and has an area of 20,580 square kilometers. Livestock in Halaieb-Shalateen-Abu Ramad Triangle is limited in sheep and goats. Aboudeleik sheep is considered one of the important breeds to produce milk and meat in the Triangle, because of their persistence to the harsh conditions (Khalil et al., 1990). The average body weight is 45 kg and the body is shallow with long legs and covered with short hair. The head, neck are long in both sexes long often with dewlap. The tail is cylindrical and long-reaching below the hocks; ears are absent or small with backward downward.

The color is dark or brown with cream; wattles are rare (DRC, 1996). The pasture in Halaieb-Shalateen-Abu Ramad triangle region contains three main plants which are poor in nutritional value, namely Panicum turgidum, Lyicum shawii and Acacia tortilis (El-Shaer et al., 1997). There is no available information about reproductive performance, production characteristics and estimates of the genetic parameter (Badawy et al., 2018). Metabolism of blood biochemical and trace minerals in sheep are still yet to be clarified under arid conditions and environmental stress during different physiological status (Samir, 1990). Trace elements supplementation has become indispensability in the feeding of ruminants (Kim and Mahan, 2002;

Boldizarova et al., 2005; Hylland et al., 2009) for the complete saturation of animals from trace elements, especially in arid and impoverished pasture areas. Trace elements play an important role in the regulation of the physiological function of ovarian activity, gestation period and the mechanism of the digestive, nervous system (Krajnicˇa'kova' et al., 2003). The decrement of trace elements diets provokes the weak of immune capacity in ewes and newborn lambs (Turner and Finch, 1990; Rodinova et al., 2008). Zinc (Zn) and copper (Cu) play important roles in many biological functions including protein synthesis, cellular division and nucleic acid metabolism (Davis and Mertz, 1987; Zhang et al., 2012). Studies on several animals such as mice, pigs and ewes concluded that severe zinc deficiency led to highly embryonic loss due to spontaneous abortions (King, 2000) and multiple congenital anomalies such as malformations of the heart, lungs, and skeletal system (McArdle et al., 2006; Jou et al., 2010). Copper (Cu) and cobalt (Co) are essential elements required for ruminant diets to enhance blood function especially lipid metabolism in sheep (Cheng et al., 2008; Abou El-Ezz and Younis, 2010), goats (Zhang et al., 2012) and cows (Wittenberg and Boila, 1988; Ward and Spears, 1997).

Also addition of trace elements such as copper (Cu) and cobalt (Co) to diets of animals led to improvement of reproductive performance of dams (Aliarabiet al.,2019; Quirk and Norton, 1987), and growth performance, quality meat, fiber characteristics in newly born (Badawy et al., 2018; Huang et al., 2014; Kadim et al., 2003). Sodium (Na^+) is the major cation of extracellular fluid, while potassium (K^+) is the major cation in the intracellular fluid. The major functions of (Na^+, K^+) ions are to regulate osmotic pressure, the acid-base balance, and maintenance of membrane potential, the transmission of nerve impulses and development of membrane potentials (Hays and Swenson, 1977).

MATERIALS AND METHODS

Animals and management

Thirty- nine Aboudeleik ewes, average body weight of 37.5 ± 3.75 kg, 3-5 years old, kept in a Ras Hederba Valley region, Shalateen Experimental Research Station, Shalateen-Halaieb -Abu Ramad Tringle Region, Red Sea Governorate, located 1300 Km of Cairo (Latitude 22, 00,720 N and longitude 36, 48.955 E). Animals were housed in semi-open pens throughout the experimental period from Sep 2016 to March 2017. Animals grazed on natural pasture about 6 hours daily and received a palliated concentrate mixture (500 gm/head/day) as basal diets (Table 1). Freshwater was presented twice daily before and after going to grazing. Animals were free of any diseases or reproductive disorders. All experimental procedures were conducted in conformity with the EU Directive for the protection of experimental animals (2010/63/EU).

Experimental design

Thirty-nine Aboudeleik ewes were randomly divided into three groups. The first group: control (n=12) received the basal diet, the second group (Organic-S; n = 14) received the basal diet that plus (2.7 gm/head/day DM) of salts additive mixtures which contain (Cu, Zn, Mg and Co) in organic form. The third group (Inorganic-S; n = 13) received the basal diet plus (2.7 gm/head/day DM) of salts mixtures (Cu, Zn, Mg and Co) in inorganic form (Active Vet, USA). The experiment started one month before mating and continued for the waning period. The chemical composition of the basal or treated diets is presented in (Table 1).

Table 1. Ingredients and chemical composition of concentrate mixture and trace elements of treated diets for Aboudeleik sheep.

Treatment diets			
Ingredient	Composition (%)	Concentrate mixture	g/kg
Yellow corn	25	Organic matter	940
Cottonseed meal	16.7	Ash	60
Wheat bran	30	Crude protein	148
Sunflower meal	25	Ether extract	55
NaCl	1	Neutral detergent fiber	534
Limestone and common salt	2	Acid detergent fiber	369
Trace minerals*	0.3	Hemicellulose	165
Trace elements (g/kg DM)	Control	Organic form	Inorganic form
P	0.71	1.25	1.67
Zn	0.63	1.35	2.00
Fe	0.42	1.25	1.00
Cu	0.62	3.75	3.33
Se	0.41	0.63	0.66
Co	0.21	0.13	0.16
Iodine	-	0.15	0.5
$Caco_3$ *	-	-	990.7
Lysine*	-	991.5	-

$Caco_3$ * (gm) = Carrier Material. Lysine* (gm) = Carrier Material.

Synchronization of estrus

All animals were estrus synchronized using double injunction (1 ml, i.m.) of prostaglandin $PGF_{2\alpha}$ (Estrumate, 263 µg Cloprostenol/ml, Schering-Plough Animal Health, Germany) 9days apart.

Estrus exhibition and mating

Exhibiting estrus was detected using tracer ram that was fitted with dye markers throughout 72 hours. Ewes that exhibited estrus were naturally mated using mature fertile rams.

Blood collection

Jugular blood samples were collected from all animals in serum vacutainer tubes 5 ml to determination progesterone concentrations (P_4) after 72 hr. of the 2^{nd} of $PGF_{2\alpha}$ injection: day 0 (Estrous – stage), day 8 (luteal-stage) and thought pregnancy stages, early (d 18-30), mid (d 60-90) and late (d 120- 150). Also, some serum biochemical and trace elements were determined throughout pregnancy stages (early– mid and late). Serum was harvested after centrifugation at 5,000 *g*. For 10 minutes, and then stored at -20 °C for later analysis.

Hormonal assay

Progesterone was analyzed using ELISA kit (Monobind, USA) according to Abraham, (1974). The intra -and inter-assay CV's are (9.7 %).

Serum biochemical and trace elements metabolic analysis

Serum samples from ewes during the experimental period were subjected to colorimetric analysis using commercial kits for the analysis of total protein (TP), albumin (Albu), globulin (Glo), total lipids (T.L), cholesterol (Cho), triglycerides (TG), urea, creatinine (Crea), aspartate amino transferase (AST), alanine aminotransferase (ALT) using commercial kits (Spectrum Biotechnology, Egypt). Phosphorous (P), calcium (Ca), selenium (Se), copper (Cu) and iron (Fe) were determined using (Inductively Coupled Argon Serum, iCAP 6500Duo, Thermo Scientific, England). The multi-element certified standard solution, Merch, Germany, was used as a stock solution for instrument standardization.

Body weight of lambs

Birth, monthly and weaning weights (90 days) were recorded using the digital balance.

Statistical analysis

Data of ewes and lambs' (birth and waning)weights, biochemical and trace elements metabolic concentrations were analyzed by the General Linear Model (GLM) procedure (SAS, 2006) using the following model:

$Y_{ijk} = \mu + G_i + S_j + G*Day_{ij} + e_{ijk}$

Y_{ijk} = observations, µ= Overall means, G_i = effect of i^{th} group (i: 1-3), S_j = effect of j^{th} status (j: 1-3), $G*S_{ij}$ = interaction between groups and status.

e_{ijk} = Experimental error. Duncan's multiple range tests were used to separate means.

Another General Linear Model procedure (SAS, 2006) was used for the statistical analysis of birth and weaning weights and average daily gain for lambs using the following model:

$Y_{ij} = \mu + Ti + e_{ij}$

Y_{ij} = any observation of j^{th} animal within the i^{th} treatment

µ = Overall mean, T_i = Effect of i^{th} treatment (i = 1-3), e_{ij} = Experimental error

Data expressed as percentages included (conception rate, lambing rate, prolificacy rate, and sex ratio) were analyzed by the chi-squared test.

RESULTS AND DISCUSSION

Changes in blood serum progesterone profile

Overall means of serum progesterone P_4 concentrations of organic or inorganic-S groups (6.38 ± 0.48 and 6.28±0.48 ng/mL, respectively) were greater (P<0.01) than that of the control group (4.36±0.48 ng/mL) (Figure 1). P_4 concentrations were affected (P<0.01) by pregnancy stages. The lowest concentration of progesterone was recorded in day 0 (0.18 ± 0.78 ng/mL) during 72 h. of the 2^{nd} of $PGF_{2\alpha}$ injection (Estrous-stages), that the concentration increased to (1.66 ± 0.78 ng/mL) on day 8 (luteal-Stage), and continued to reach (10.00 ± 0.78 ng/mL) at day 90 (mid-stage), that declined to (8.88 ± 0.78 ng/mL) on day 150 (late-stage) (Figure.1). The interaction effect between treatment and pregnancy stages was not significant.

The increase observed in serum P_4 concentration might be attributed to the increase of cholesterol concentration (Table 1), which is a precursor of P_4 hormone synthesis (Abayasekara and Wathes, 1999). However, among different pregnancy stages, there was a significant increase in serum P_4 concentrations in all experimental groups with the advancement of pregnancy stages. Similar findings were reported by Abd El-Hamid et al. (2016); Kandiel et al. (2016) in sheep and Abd El- Hamid et al. (2017) in goats. Progesterone concentration during pregnancy in sheep is a substantial contribution from the placenta-fetal unit (Linzell and Heap, 1968). It was reported that P_4 concentration in sheep serum during the first term of pregnancy is comparable to those found during the luteal- stage (8 d) of the estrous cycle (Bazer and First, 1983) suggesting that corpus luteum is the main source of P_4 to maintain pregnancy during this period. However, there was an increase in P_4 concentration on early-stage (18-30 d) after mating which occurs in pregnant ewes (Bassett et al., 1969). The level of serum P_4 is increased steadily in mid-stage of pregnancy (60- 90 d), the placenta is the major source of P_4 (Ricketts and Flint, 1980), and placental secretion of P_4 during this stage is more than the ovarian contribution (Linzell and Heap. 1968). In late-stage (120-150 d) of pregnancy, serum P_4 concentration was started to decline for preparation of the parturition process (Boulfekhar and Brudieux, 1980).

Reproductive performance

Our results showed that the conception rate increased (P<0.05) in organic and inorganic salts groups (100%) compared with control (91.67%). While lambing and prolificacy rates increased (P<0.05) in inorganic-S group (92.31 & 100 %, respectively) compared with organic-S (85.71 & 92.9 %, respectively) and control (83.33 & 91.6%, respectively). No significant difference was detected in the sex ratio of the experimental groups (Figure. 2).

It is well known that trace elements play important roles for fertility during the breeding season (Kumar, 2003). Our results, concerning the improvement of ewes' reproduction, were in agreement with studies in other species. Rodinova et al. (2008) reported that lambing rate of primiparous Sumavka ewes fed diet supplemented with selenium (Se) in organic or inorganic forms (180 mg/h/d of DM basis) during pregnancy period was improved compared with the control group. Moreover, Senosy et al. (2018) demonstrated that reproductive performance including a number of services/conceptions, pregnancy rate was significantly improved as a result of organic bound phosphorous injection twice a week for successive three weeks in Farafra ewes. Additionally, Phiri et al. (2007) found that reproductive performance was improved by calcium, phosphorus, and zinc supplementation in dairy cows' diets. Similar results were found in Merino ewes by master's and Fels (1980). These findings are in agreement with the present results and may be attributed to increase in numbers and sizes of ovarian follicles and size of corpora lutea (Senosy et al., 2018 and Dunn & Moss, 1992), and enhance of antioxidants status by supplementation of Cu in the diet goats without producing any toxic signs, which led to decrease of reactive nitrogen species (RNS) and reactive oxygen species (ROS), thus improve of reproductive characteristics (Yoshikawa and Naito, 2002). These results are supported by data of serum phosphorus, copper levels presented in (Figure 3).

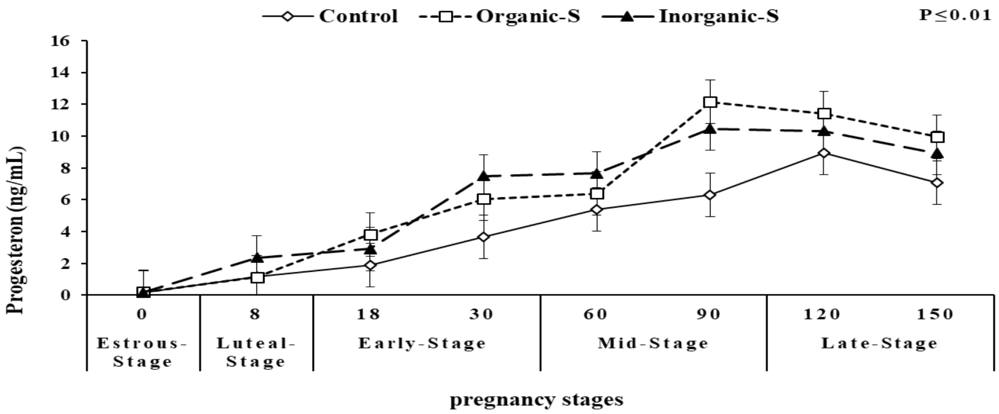

Figure 1: Changes in serum progesterone (P_4) concentrations in Aboudeleik ewes during pregnancy at days (0d=Estrous–stage, 8d=Luteal-stage, 18-30d= Early-stage, 60-90d=Mid-stage and 120-150d=Late-stage of pregnancy.

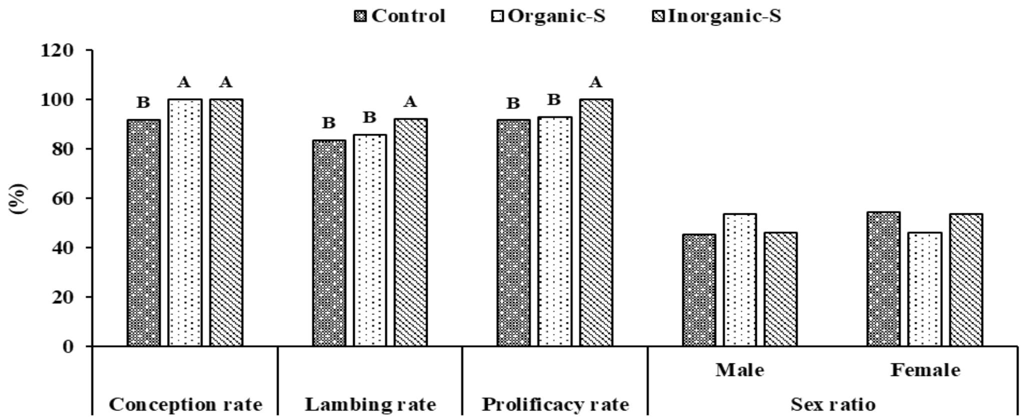

Figure 2: Percentages of reproductive performance including conception, lambing prolificacy rates, and sex ratio of Aboudeleik ewes fed a control diet or a diet supplemented with trace-elements in organic or inorganic forms.

$^{A-B}$ letters among groups differ significantly (P<0.05).

- Conception rate = a number of ewes conceived / number of ewes showing estrus and mated ×100.
- Lambing rate = number of ewes lambed / number of ewes mated ×100.
- Prolificacy rate =number of lambs born/number ewes lambed ×100.

Changes in serum biochemical constituents

Overall means of serum total proteins (TP, g/dL), albumin (Albu, g/dL), globulin (Glo, g/dL), urea (mg/dL) and serum aspartate (AST) and alanine (ALT) aminotransferase levels did not differ significantly among experimental groups due to treatment, stage of pregnancy and the interaction between them (Table 2).

It is worthy of mentioning that our values were within the reference values (Table 2) during different stages of pregnancy in ewes under arid condition (El-Sherif and Assad, 2001).

The obtained resulted demonstrated that control group had higher (P<0.05) serum creatinine (Crea, mg/dL) concentration (2.16±0.09 mg/dL) than those for organic or inorganic-S groups (1.98±0.09, 1.83±0.09 mg/dL, respectively). However, the stage of pregnancy or the interaction between treatment and pregnancy stage didn't reveal any significant effects on serum creatinine concentration (Table 2).

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Higher serum creatinine in control group was previously observed in the arid zones because of nutritional deprivation, lack of natural pasture protein, water restriction, stress (Ndlovu et al., 2009; Abdel-Fattah, 2008 and Thrall et al., 2004). However, phosphorous administration as trace element led to decrease the serum creatinine. As a result, to improve nitrogen utilization (Senosy et al., 2018). On the other hand, supplemented groups had higher (P<0.05) overall means of serum total lipids concentration (T.L, mg/dL) than the control group with values being (655.32 ± 52.58, 648.83±52.58 and 557.29±52.58 mg/dL) for organic, inorganic and control groups, respectively. Serum total lipids concentrations were affected (P<0.01) by pregnancy stages where the highest values were recorded at late and mid stages (732.42±52.58 and 644.90±0.52.58 gm/dL, respectively), while the lowest value was recorded in early stage (484.13±52.58 gm/dL). There was no significant effect due to the interaction between treatment and pregnancy stages. The overall means of serum cholesterol (Cho, mg/dL) concentration was increased (P<0.05) in ewes fed diet supplemented with organic or inorganic salts (72.73±2.64 and 69.75±2.64 mg/ dL, respectively) as compared to control group (59.73±2.64 mg/ dL) (Table 2). Stages of pregnancy and the interaction between treatment and pregnancy stares didn't affect serum cholesterol concentration significantly. The same trend was noted in the overall mean of serum triglycerides concentration (TG, mg/dL) Table (2).

Similar findings were reported in different Species in lambs (Cheng et al., 2008) and goats (Zhang et al., 2012) or in goat kids (Datta et al., 2007 and Mondala et al., 2007). In our results the serum cholesterol concentration (Cho) increased, those results are in agreement with (Amer et al., 1973 and Abdel-Mageed et al., 1990). Regulation of cholesterol synthesis in ruminants is controlled with many factors, such as animal's antioxidant status especially glutathione peroxidase (GSH) and diets content of trace elements (Panev et al., 2013), which are mainly related to activity of the enzyme 3-hydroxy-3-methyl- glutaryl coenzyme A (HMG-CoA) in tissues, increased intestinal secretion of lipoproteins with higher contents of triglycerides led to increase in Cho concentration (Starry, 1981).

Table 2. Least square means ± SE of Serum biochemical concentrations of pregnant Aboudeleik ewes fed a control diet or a diet supplemented with trace-elements in organic or inorganic forms during different pregnancy stages (M±ES).

Items	Groups	Days of pregnancy period						*P value*		
		Early-stage (18–30 d)	Mid-stage (60–90 d)	Late-stage (120–150 d)	±SE	Overall	±SE	G	S	G×S
TP (g/dL)	Control	6.32	5.91	6.03	0.32	6.09	0.18	0.20	0.40	0.31
	Organic-S	6.33	5.62	6.27		6.07				
	Inorganic-S	5.79	5.98	5.19		5.65				
	Overall	6.15	5.83	5.83	0.18					
Alb (g/dL)	Control	4.76	4.62	4.59	0.44	4.65	0.25	0.60	0.20	0.48
	Organic-S	3.76	4.36	4.93		4.35				
	Inorganic-S	3.81	4.35	3.74		3.97				
	Overall	4.11	4.44	4.42	0.25					
Glo (g/dL)	Control	1.56	1.29	1.44	0.43	1.34	0.24	0.14	0.68	0.66
	Organic-S	2.56	1.26	1.33		1.72				
	Inorganic-S	1.98	1.62	1.44		1.68				
	Overall	2.03	1.39	1.40	0.24					
T.L (mg/dL)	Control	510.65	483.54	677.68	91.07	557.29^{B}	52.58	0.05	0.01	0.07
	Organic-S	401.12	633.98	900.88		655.32^{A}				
	Inorganic-S	540.61	787.17	618.70		648.83^{A}				
	Overall	484.13^{Y}	732.42^{X}	644.90^{X}	52.58					
Cho (mg/dL)	Control	51.93	66.96	60.31	4.58	59.73^{c}	2.64	0.05	0.33	0.62
	Organic-S	72.13	77.46	68.83		72.73^{A}				
	Inorganic-S	74.39	72.42	62.46		69.75^{B}				
	Overall	66.15	72.28	63.86	4.58					
TG (mg/dL)	Control	39.67	31.38	24.88	8.77	31.97^{C}	10.13	0.05	0.33	0.87
	Organic-S	56.78	39.34	65.68		53.97^{A}				
	Inorganic-S	37.30	31.87	64.41		44.52^{B}				
	Overall	44.58	34.19	51.65	10.13					
Urea (mg/ dL)	Control	60.10	44.14	50.06	4.26	51.43	2.46	0.65	0.53	0.07
	Organic-S	45.08	54.86	51.02		50.32				
	Inorganic-S	56.81	54.09	49.69		53.53				
	Overall	53.99	51.03	50.25	2.46					
Crea (mg/ dL)	Control	2.48	2.14	1.87	0.15	2.16^{A}	0.09	0.05	0.86	0.10
	Organic-S	1.87	2.01	2.05		1.98^{AB}				
	Inorganic-S	1.73	1.80	1.96		1.83^{B}				
	Overall	2.03	1.98	1.96	0.09					
AST (IU/L)	Control	57.97	68.66	79.86	5.88	68.83	3.39	0.44	0.68	0.10
	Organic-S	71.84	77.32	68.52		72.56				
	Inorganic-S	71.81	61.47	65.79		66.35				
	Overall	67.21	69.15	71.39	3.39					
ALT (IU/L)	Control	78.94	73.67	86.05	8.07	79.40	4.66	0.54	0.95	0.75
	Organic-S	79.56	87.88	82.71		83.38				
	Inorganic-S	90.13	85.87	84.47		86.82				
	Overall	82.73	82.47	84.41	4.66					

$^{A-C}$ values with different superscript letters in the same column are statistically different (P <0.05).
$^{X-Y}$ values with different superscript letters in the same rows are statistically different (P <0.05).

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Changes in serum mineral concentrations during pregnancy stages

The present results showed that G3 (inorganic-S) achieved the highest overall mean values of serum calcium (0.81±0.15 mg/dL) followed by control and organic-S, respectively (0.72±0.15 and 0.50±0.15, mg/dL). However, the difference due to treatment, stages of pregnancy and the interaction between them were not significant. Serum selenium concentrations demonstrated that treated ewes had exceeded their counterparts of control ones with values being 10.32± 0.70, 8.73 ± 0.70 and 8.64 ± 0.70 mg/dL for and inorganic-S, organic-S and control groups in order. No significant differences among treatment groups or stages of pregnancy were recorded. Furthermore, the interaction between treatment and pregnancy stages was not significant. The same trend was found in the overall means of serum iron concentrations inorganic-S group recorded the highest value (60.22±0.90, mg/dL) followed by organic-S group (52.44±0.90, mg/dL) which the lowest Fe concentration was recorded for the control group (47.83±0.90, mg/dL). There were no significant effects of pregnancy stages and the interaction between pregnancy stages and treatments (Figure 3). The overall means of serum phosphorus concentration declared that organic-S group had higher ($P<0.01$) value of P (5.23 ± 0.29 mg/dL) than the control or inorganic-S groups (2.37 ± 029 and 3.72 ± 0.29 mg/dL respectively). Pregnancy stages and the interaction between treatment and stages of pregnancy didn't have any significant effects on P values. The present findings revealed that serum copper (Cu) concentration took the same pattern of P inorganic-S group had the highest Cu value (3.42±0.40, mg/dL, respectively) compared with control ones (1.84±0.40 mg/dL) (Figure 3). The differences among groups were significant ($P<0.01$). However, the difference due to pregnancy stages and the interaction between treatment and pregnancy stages were not significant (Figure. 3).

These findings are in agreement with previous reports in different animal species, in sheep (Senosy et al., 2018; Abdelrahman et al., 2017 and Jalilian et al., 2012), in goats (Pechova et al., 2009), in kids goats (Strnadová et al., 2011; Palenikova et al., 2014), in dairy cows (Kinal et al., 2007). Increasing of serum concentration of phosphorus and copper are due to supplementation of microelements with the bioavailability of microorganisms in rumen led to better transfer of trace elements to the tissues, including blood (Spears, 1996; Olson et al., 1999; Huert et al., 2002).

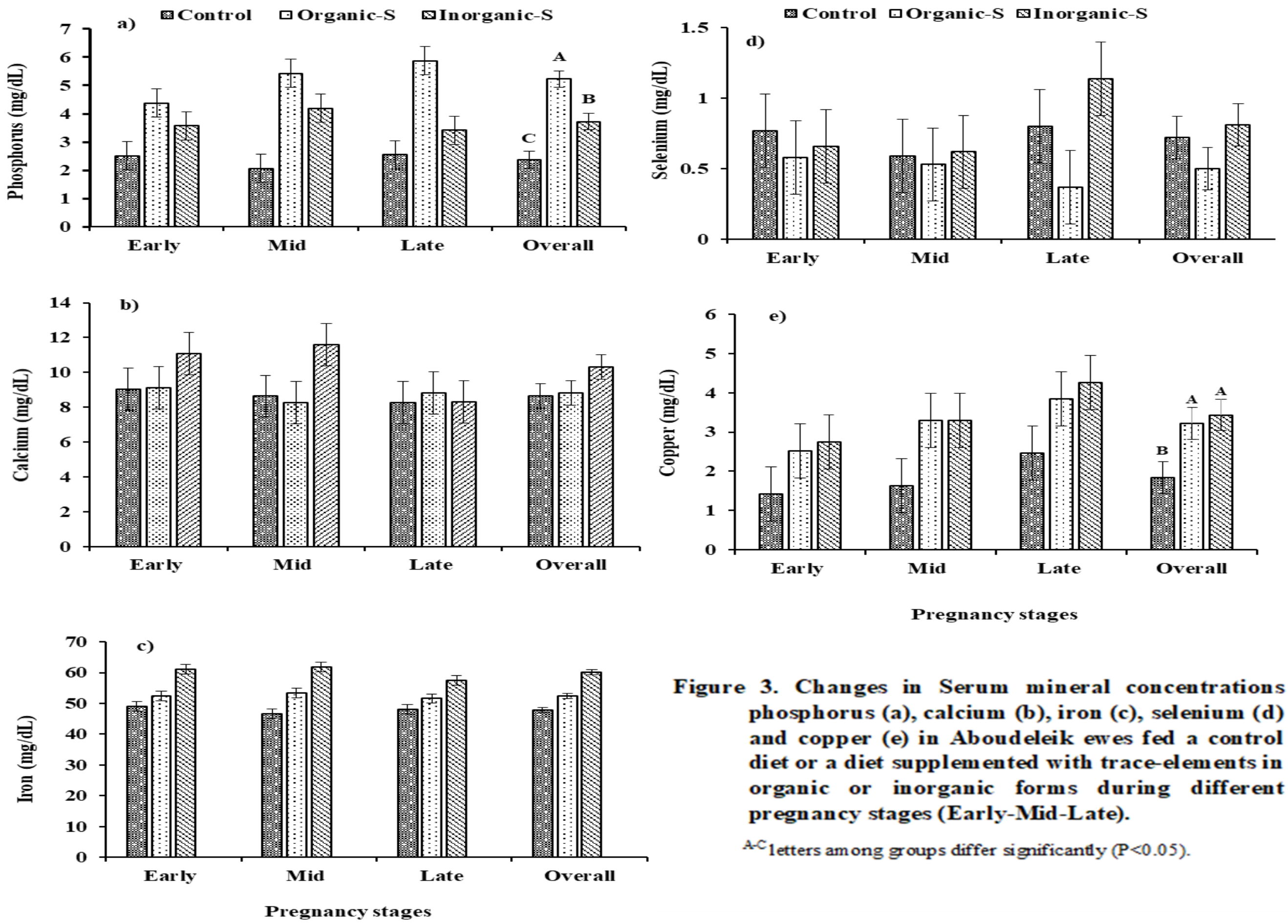

Figure 3. Changes in Serum mineral concentrations phosphorus (a), calcium (b), iron (c), selenium (d) and copper (e) in Aboudeleik ewes fed a control diet or a diet supplemented with trace-elements in organic or inorganic forms during different pregnancy stages (Early-Mid-Late).

A-C letters among groups differ significantly ($P<0.05$).

Productive traits of newly born lambs

Birth weight for lambs born from ewes supplemented with organic salts was higher ($P<0.05$) (2.89± 0.12kg) than lambs born from ewes supplemented with inorganic-S (2.72 ± 0.11 kg) or control ewes (2.49 ± 0.12 kg). No significant effect of treatment × time interaction was observed on lamb's body weights. Concerning the values of weaning weight and average daily gain, the present results demonstrated that lambs born from ewes supplemented with organic and inorganic salts achieved higher ($P<0.05$) weaning weight (15.30 ± 0.64, 14.54 ± 0.62 Kg, respectively) and average daily gain (137.5± 0.01, 130.8 ± 0.01 gm, respectively) compared with lambs born from control ewes (12.58± 0.67 Kg and 111.7 ± 0.01 gm) (Table 3).

Average body weight of kids born to goat dams fed (30 mg Cu/ kg DM) inorganic or organic forms were higher (Palenikova et al., 2014; Solaiman et al., 2007). Moreover, kids supplemented (60 mg Zn/ kg DM) organic or inorganic forms with diets showed significantly higher average daily gain compared with control (Strnadová et al., 2011). While growth performance of (Dorper × Mongolia) lambs fed (10 or 20 mg Cu/kg DM) to the basal diet did not differ (Cheng et al., 2008). The present results revealed that growth performance increased significantly towards the end of lactation period (3 month). It has been documented that, newborn of lambs is dependent upon their dams for transfer of these nutrients via the placenta and the mammary gland (Rock et al., 2001; Jalilian et al., 2012). Furthermore, the highest growth rate and waning weight of lambs during the first three months of life, are affected by many factors such as number of lambs born per ewe (Datta et al., 2007), improved of immunity to newly born from dams feeding with by P, Cu and Zn in organic or inorganic forms (Senosy et al., 2018; Strnadová et al., 2011). Supplementation of trace elements had a positive impact on quality milk or milk fat content (Antunovic et al., 2017; Kinal et al., 2007; Wiking et al., 2008; Pechova et al., 2009). After the first few months the newborn became progressively less dependent on the mother milk, as its consumption of solid food increase (Owen. 1976). Huang et al. (2014) reported that supplementation of higher Cu led to positive changes in intramuscular fat content (PUSFA), meat growth, carcass characteristics and meat quality of goat kids. However, the mechanism of improvement is unknown.

Table 3. Productive traits of newly born lambs' born from Aboudeleik fed a basic diet or supplemented with trace elements in organic or inorganic forms during the early lactation period (LSM±SE).

Traits	Treatments			*P* value
	Control	Organic-S	Inorganic-S	
Birth weight (kg)	$2.49^{B} \pm 0.12$	$2.89^{A} \pm 0.12$	$2.72^{AB} \pm 0.11$	
Weaning weight (Kg)	$12.58^{B} \pm 0.67$	$15.30^{A} \pm 0.64$	$14.54^{A} \pm 0.62$	0.05
Average daily gain (gm)	$111.7^{B} \pm 0.01$	$137.5^{A} \pm 0.01$	$130.8^{A} \pm 0.01$	

$^{A-B}$ values within the same row with different letters differ (P<0.05).

CONCLUSIONS

It could be concluded that the salts rich in phosphorus, copper and zinc in organic or inorganic forms supplemented to Aboudeleik ewes during different pregnancy stages increased serum progesterone profile, blood lipid metabolites including total lipids, cholesterol and triglycerides concentrations and serum phosphorus, copper concentrations. Reproductive performance including (conception, prolificacy and lambing rates) and productive traits of newly born lambs including Birth, weaning weights and average daily gain were improved.

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