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Effect of Supplementation Different Forms of Selenium on Reproductive Performance of Zaraibi Goats

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ABSTRACT

Forty Zaraibi goats having 3 years old and 41 kg live body weight (LBW) were used. Goats were placed into similar five groups based on their age, body weight, (8 does / group) which the control group were fed on basal diet containing 0.17 mg Se/kg DM. The treated goats fed on the same basal diet plus the treatment with Se as follows: First group (G1): as a control group without any treatment. Second group (G2): goats were injected with 0.1 mg of selenium (sodium selenite) per kg LBW. Third group (G3): goats were injected with 0.2 mg of selenium (sodium selenite) per kg LBW. Fourth group (G4): goats were given oral dose of Nano-selenium (Na-Se, 0.1 mg/kg LBW). Fifth group (G5): goats were given oral dose of Na-Se (0.2 mg/kg LBW).

Values of the percentage of does that came in estrus following treatment were significantly higher ($P<0.05$) in G3, G4, and G5 (100%) than G2 treatment group (87.5%), however, relatively low estrous activity for does has occurred on control group G1 (75%). In does treated with Na-Se kidding rate of the highest value in September experiment (2.25) for G4 and G5 while gradually decreased reaching 1.71 and 1.66 for G2 and G3 and the lowest value in kidding rate 1.16 for G1 (control). Does in all treatment groups (G2, G3, G4 and G5) has single birth (16.7, 14.3, 12.5 and 12.5%) compared with those in G1 significantly ($P<0.05$) produced more single birth (60%). However, does which have the highest value of twins birth was G2 (66.7%) with significantly differences ($P<0.05$), while G3, G4 and G5 have 57.1%, 50% and 50% compared with the lowest value of twins (40%) on controls (G1). Its worth to note that does which produce triples was 16.6, 28.6, 37.5 and 37.5% for G2, G3, G4 and G5. Does in all treatment groups, except those in G5 significantly ($P<0.05$) produced more female kids (61.1%) and less male kids (38.9%) than the other treatment or control group. The values were 42.9, 58.3, 40 and 55.5% male for G1, G2, G3 and G4, respectively.

On overview, the obtained results indicated that the supplementation positively improved reproduction performance. It was concluded that Na-Se can be used as a alternatively available source in Zaraibi goats.

INTRODUCTION

Goats are an important source of meat and milk. Since nutritional requirements vary throughout the reproductive cycle, strategic feed supplementation can also be an important tool to improve reproductive efficiency. Nutrition is generally recognized as a significant regulator of reproduction **(Smith and Akinbamijo, 2000)** and that improvement in the nutritional status of the does, particularly preceding mating, is known to increase fertility in small ruminants due to dynamic effects of nutrition on ovulation rate **(Kusina *et al.*, 2001)**. Responses to flushing, however, are often variable and inconsistent depending on factors such as genotypes **(Chemineau *et al.*, 2004)**, body conditions of the animals **(O'Callaghan *et al.*, 2000)**, timing and duration of flushing **(Karikari and Blasu, 2009)**, the amount and quality of dietary supplements for example, energy and protein levels **(Acero-Camelo *et al.*, 2008)**. There is, however, scanty information on the effects of nutrition and seasonal influences on the productivity and reproduction of goats.

Egyptian Nubian (Zaraibi) goats, known to be a progenitor of the standard Anglo-Nubian, are raised as the household dairy animals in the North-East of the Nile Delta and are known for their high prolificacy **(Aboul-Naga *et al.*, 2012)**. Zaraibi goats is considered one of the best milk producers under Egyptian conditions, yielding 263 Kg milk in a 260-day lactation period, with an average litter size of 2.3 **(Hamed, 2005)**.

The reproductive performance of goats is a major determinant of the productivity and economic viability of commercial goat farms. The reproductive process is regulated by genetic and environmental factors and the net effect of all these influences determines the level and efficiency of reproduction. Fertility in healthy goatherds is influenced by prepuberal and postpartum nutrition **(Bocquier *et al.*, 1996)**.

Although goats can tolerate moderate weight losses at mating and still get pregnant **(Goonewardene *et al.*, 1997)**, more severe changes in energy intake during pregnancy markedly affect fetal survival, thus abortions and stillbirths are major causes of economic loss for the goat industry under intensive **(Engeland *et al.*, 1998)** and extensive **(Mellado *et al.*, 2001)** production systems.

Ruminants are often supplemented with trace minerals to maintain health, productivity, and profitability. Trace minerals can be supplemented in an oxide form but compared to other forms available, such as sulfate, oxides have a relatively low bioavailability. Selenium (Se) is an essential trace element that is present in small amounts in the mammal body. The mineral cannot be formed by the organism, so it has to come from dietary sources. Most of the Se in animals is tied to proteins which therefore are called seleno-proteins or seleno-containing proteins depending on the amino acid. The definition of a seleno-protein is that selena-cysteine (Se-Cys) is incorporated in the protein. This incorporation is specific and mediated at a ribosomal level and more than 80% of the protein bound Se is Se-Cys **(Hefnawy and Tórtora-Péres, 2010)**.

Se is a component of seleno-proteins and is involved in immune and neuropsychological functions in the nutrition of animals **(Meschy, 2000)**. Most of the seleno-proteins have enzymatic functions and therefore they are also called seleno-enzymes. These enzymes are involved in different metabolic pathways in mammal organisms **(Hefnawy and Tórtora-Péres, 2010)**.

Selenium deficiency plays a role in numerous economically important livestock diseases, problems that include impaired fertility, abortion, retained placenta, and neonatal weakness **(McDowell *et al.*, 1996)**. Among all the probable approaches, the use of nano-technology to produce nano-sized Se called Nano Se (NP-Se), is a potential alternative to both organic and inorganic Se sources.

Selenium can be supplemented in animal diets in two forms: inorganic forms such as sodium selenite, or organic bounded forms such as selenomethionine, lactate-protein Se complex, Se-proteinate, Se-enriched yeast, and Se-enriched alga **(Faixová *et al.*, 2016 and Kachuee *et al.*, 2019)**. The organic forms of Se are safer and can be passed into milk **(Sun *et al.*, 2017 and Ianni *et al.*, 2019)**, but the inorganic Se is the most common form used in dairy animals as feed supplementations because of the higher rate of reaction than the organic Se sources.

In this respect, producing bio-nano-structured selenium (SeNSM) is a new direction of the green chemistry used for enhancing the Se biological activity **(Malyugina *et al.*, 2021)**. Products of SeNSM exhibit various vital functional properties (e.g., antioxidant, antimicrobial, and anti-inflammatory) therefore, they were considered safe feed supplements for livestock **(Malyugina *et al.*, 2021 and Boroumand *et al.*, 2019)**.

The objective of this study was to investigate the effect of some non-genetic factors associated with the likelihood of pregnancy, milk production, milk composition and litter size for Zaraibi goats by evaluating of reproductive performance of Zaraibi goats by comparing the effect of two doses of selenium 0.1 or 0.2 mg/kg injection mineral source or nano source orally.

Materials and Methods:

Zaraibi goats were taken from the flock of Mehalet Mousa Experimental Station, Kafrelsheikh Governorate, belonging to the Animal Production Research Institute (APRI), Ministry of Agriculture in cooperation with the Animal, Poultry and Fish Production Department, Faculty of Agriculture, Damietta University, Egypt during the period from September 2022 until July 2023. The experiment was conducted according to the guidelines of the Egyptian Research Ethics Committee and the instructions contained in the Guide for the Care and Use of Laboratory Animals (2011).

Feeding system:

Does were fed a basal ration consisting of 40% concentrate feed mixture (CFM) beside 60% fresh berseem (FB, *Trifolium alexandrinum*) during winter feeding (November-April) or 50% CFM and 50% berseem hay (BH) or rice straw during summer feeding (May-October). The CFM consisted of cotton seed cake, linseed cake, yellow corn, wheat bran, molasses, calcium chloride and common salt. Goats were fed according to NRC feeding requirements **(NRC, 2001)**.

Animals and experimental treatment:

Forty Zaraibi goats 3 years old and 41 kg live body weight were used to study the effect of injection of each goat with 0.1 or 0.2 mg of selenium (sodium selenite) or an oral dose of 0.1 or 0.2 mg of Nano-selenium per kg live body weight on productive and reproductive performance of goats (response %, conception rate, fertility %, litter size, and kidding rate) was recorded. These dams were selected before the September breeding season, which starts on 1st September with natural mating, so the treatment with selenium was given at four stages first: 2 weeks before start of mating season, second: at 21 days after mating, third: 2 weeks pre kidding and forth: 2 weeks post kidding, the experiment continued until the completion of the birth goats and weaning of kids.

Experimental design:

Forty goats were assigned randomly placed into similar five groups based on their age and body weight, (8 does / group) which and the control group was fed on a basal diet containing 0.17 mg Se/kg DM. The treated goats fed on the same basal diet plus the supplemented with Se as follows:

- First group (G1): as a control group without any treatment.
- Second group (G2): goats were injected with 0.1 mg of selenium (sodium selenite) per kg LBW.
- Third group (G3): goats were injected with 0.2 mg of selenium (sodium selenite) per kg LBW.
- Fourth group (G4): goats were given an oral dose of Nano-selenium (0.1 mg/kg LBW).
- Fifth group (G5): goats were given an oral dose of Nano-selenium (0.2 mg/kg LBW).

During the breeding season, estrus was monitored by the presence of a mature buck with the experimental goats and the proportion of goats in estrus was recorded in each group, they were naturally mated during September breeding season of six weeks (1st September to 15th October) to study the effect of treatments of reproductive performance of goats.

Reproductive parameters:

All does were allowed for natural mating. The does were exposed to fertile bucks from the contemporary to that of start time up to the end of the breeding season (15 October). During the breeding season, Zaraibi bucks of proven fertility was introduced to does until the end of the experiment. Does of all groups were detected for the onset of oestrus and hand mating was applied for those coming in oestrus.

- Estrus response: number of goats showed estrus / total number of goats x 100.
- Conception rate: number of pregnant goats / number of mated goats x 100.
- Fertility (%): number of pregnant goats / number of total goats x 100.
- Litter size: the number of kids born / kidded goats.
- Kidding rate: number of kids born / number of goats mated x 100.
- Type of birth: the single or twins or triplet of kids /kidding does of each group x 100.
- Sex ratio: the male and female number of kids /total number of kids of each group x 100.

Statistical analysis:

Data were analyzed using SAS (1999) and GLM. Analysis of variance. Duncan Multiple Range test (Duncan, 1955) was used to get the mean separations among the effects of treatment for the studied traits.

Result and Discussion

Reproductive performance of zaraibi goats as affected by both Se forms supplementation:

a- Estrous activity, conception rate and fertility rate:

Results in Table (1) show the effect of the different treatments on the estrus rate of goats during the September breeding season. Data in Table (1) represent a comparison between the treatments in their effect on treated does in terms of the occurrence of estrus activity and mated does.

Occurrence of estrus has been expressed as the percentage of does that showed estrous behavior out of those treated. Values of the percentage of does that came in estrus following treatment were significantly higher ($P<0.05$) in G3, G4, and G5 (100%) than G2 treatment group (87.5%), however, relatively low estrous activity for does has occurred on control group G1 (75%).

Mean values of conception rate and fertility in does of different treatment groups are presented in Table 1.

Conception rate has been expressed as the percentage of does kidded out of those exposed to estrus activity. Data in Table 1 show that does treated with injected Se (G2 and G3) were close (85.7 and 87.5%) for G2 and G3, however, equal values of conception rate (100%) in G4 ad G5 with significantly higher ($P<0.05$) than those on controls (83.3%).

Table (1): Estrus activity, pregnancy rate ad fertility of Zaraibi goat dams as affected by both Se forms supplementation.

Group	N(1)	Estrus activity		Conception rate 3/2		Fertility rate 3/1
		N(2)	%	N(3)	%	%
G1	8	6	75.0[b]	5	83.3[b]	62.5[b]
G2	8	7	87.5[ab]	6	85.7[ab]	75.0[b]
G3	8	8	100[a]	7	87.5[ab]	87.5[ab]
G4	8	8	100[a]	8	100[a]	100[a]
G5	8	8	100[a]	8	100[a]	100[a]

a and b: Means denoted within the same column with different superscripts are significantly different at ($P<0.05$). N: Total number of treated does.

The fertility rate has been expressed as the percentage of does kid out of a total number of treated does. Equal values of fertility rate for both treatment groups G4 and G5 were recorded (100%). On the other hand, treatment with G2 and G3 resulted in a higher fertility rate (75% and 87.5%) than that on controls (62.5%).

There is a significant seasonal variation in the responsiveness of the hypothalamic-hypophysis axis to the negative feedback action of E_2 on LH secretion, which appears to be mainly dictated by the photoperiod (**Herbison, 1995**). During seasonal anestrus, LH continues to be released but with a lower frequency than during the follicular phase of the cycle during the breeding season (**Rosa and Bryant, 2003**). The low level of E_2 was observed during seasonal anestrus, resulting in the short and long-term suppression of GnRH and gonadotrophin release (**Clarke and Tilbrook, 2009**) and a marked change of hypothalamic responsiveness to estradiol alone can be observed.

The transition from anestrus to estrous activity is gradual with the occurrence of an initial short cycle as the first CL regresses prematurely 5-6 days after its formation. It is only after the 1st ovarian cycle that behavioral estrus is exhibited (**Rosa and Bryant, 2003**). E_2 is also responsible for estrous behavior in all species including sheep; however, small amounts of P_4 priming are necessary for the induction of estrus in sheep during the first reproductive cycle of the breeding season (**Herbison, 1995 and Stellflug *et al.*, 1997**). The absence of ovulation during seasonal anestrus is thought to be due to the reduced frequency of LH pulses (**Wallace *et al.*, 1985**). By the present results, **Arellano-Rodriguez *et al.* (2007**) found that Beta-carotene supplementation positively affects ovarian activity in goats.

b- Litter size and kidding rate of zaraibi goats:

It is the worth noting that the results of litter size have been expressed as a number of kids born per doe kidded. Mean values of litter size were generally higher in does treated Se than those in untreated (G1). Differences between treatments were non-significant (2.00-2.25 *vs*. 1.4) (Table 2).

The results of the kidding rate have been expressed as a number of kids born per doe mated (Table 2). In does treated with Na-Se kidding rate of the highest value in the September breeding season (2.25) for G4 and G5 gradually decreased reaching 1.71 and 1.88 for G2 and G3 and the lowest value in the kidding rate of 1.16 for G1 (control).

Table (2): Effect of different Se treatments on litter size and kidding rate of Zaraibi goats.

Group	Mated does(1)	Kidding does(2)	Number of kids(3)	Litter size3/2	Kidding rate3/1
G1	6	5	7	1.40[b]	1.16[b]
G2	7	6	12	2.00[a]	1.71[a]
G3	8	7	15	2.14[a]	1.88[a]
G4	8	8	18	2.25[a]	2.25[a]
G5	8	8	18	2.25[a]	2.25[a]

a and b: Means denoted within the same column with different superscripts are significantly different at (P<0.05).

The oxidative stress may occur at different sites, at different times, and by different mechanisms in the animal system. Levels of the antioxidant vitamins are associated with fertility and production levels in ruminants including sheep. These antioxidants need to be replenished / regenerated or supplemented at appropriate times to optimize the ruminant health and productive / reproductive performance (**Nayyar and Jindal, 2010**).

Since Se works in cooperation with other antioxidants, its administration in diseases which are followed by oxidative stress is more effective when used in combined preparations. **Qureshi *et al.* (2010)** reported that there was complete protection in the entire component of the ovaries and there was also a significant increase in a number of different types of developing follicles in deficient animals.

Selenium has been amply documented to significantly enhance animal development, a number of metabolic processes, and reproductive success **(Grela and Sembratowicz 1997)**. Administration of Se improves reproductive performance in ewes **(Gabryszuk and Klewiec, 2002; Koyuncu and Yerlikaya, 2007**).

c- Effect of treatments on type of birth and sex ratio of zaraibi goats:

Results revealed that the effect of treatment on the type of birth of produced kids was significant (P<0.05). Does in all treatment groups (G2, G3, G4 and G5) have single birth (16.7, 14.3, 12.5 and 12.5%) compared with those in G1 significantly (P<0.05) produced more single birth (60%). However, does which have the highest value of twins birth was G2 (66.7%) with significant differences (P<0.05), while G3, G4 and G5 have 57.1%, 50% and 50% compared with the lowest value of twins (40%) on controls (G1). It's worth noting that does which produce triples were 16.6, 28.6, 37.5 and 37.5% for G2, G3, G4 and G5. Concerning the type of birth, does in the control group did not produce triple kids. Does in all treatment groups significantly (P<0.05) produce higher triple and lower single births than that in the control group (Table 3).

Results in Table (4) reveal that the effect of treatment on the sex ration of produced kids was significant (P<0.05). Does in all treatment groups, except those in G3 and G5 significantly (P<0.05) produce more female kids (61.1%) and fewer male kids (38.9%) than the control group. The values were 42.9, 58.3, 40 and 55.5% male for G1, G2, G3 and G4, respectively.

Table (3): Effect of different Se treatments on type of birth of Zaraibi goats.

Group	Number of kidding does	Type of birth					
		Single		Twins		Triple	
		N	%	N	%	N	%
G1	5	3	60.0[a]	2	40.0[b]	0	0.00
G2	6	1	16.7[b]	4	66.7[a]	1	16.6[b]
G3	7	1	14.3[b]	4	57.1[ab]	2	28.6[ab]
G4	8	1	12.5[b]	4	50.0[ab]	3	37.5[a]
G5	8	1	12.5[b]	4	50.0[ab]	3	37.5[a]

a and b: Means denoted within the same column with different superscripts are significantly different at (P<0.05).

Table (4): Effect of different Se treatments on sex ratio of Zaraibi goats.

Group	Number of kids[3]	Sex ratio			
		Male		Female	
		N	%	N	%
G1	7	3	42.9[ab]	4	57.1[ab]
G2	12	7	58.3[a]	5	41.7[b]
G3	15	6	40.0[b]	9	60.0[a]
G4	18	10	55.5[a]	8	44.5[b]
G5	18	7	38.9[b]	11	61.1[a]

a and b: Means denoted within the same column with different superscripts are significantly different at (P<0.05).

Number or percentage of kids (males and females, single, twins and triplets) at birth as affected by feeding their dams on different experimental rations during the pre-partum period and the treatment with Se. The results showed that treatment does yield the highest total number of kids with the lowest average LBW/kid, while the control does show an opposite trend. Such findings are in relation to litter size. It is of interest to note that resulted in some change in the sex ratio of produced kids, where this group produced greater males than females and the sex ratio was 58.3: 41.7 male: female (G2) versus 42.9: 57.1 in control.

In agreement with the present results, **Al-Caisy *et al.* (2001)** and **Jawasreh (2000)** observed the superiority of Awassi males and singles in their birth weights over females and twins, respectively. The effect of sex in birth weights may due to sex hormones affect namely P4 and E2 that affect the metabolism of embryos and newborn as well as adult animals (**Hafez, 1996**).

In general, lamb body weight gains until weaning reflect the milk production ability of their dams **(Snowder and Glimp, 1991)**. It was reported that Se is transported to the offspring (lambs) along two pathways: via the placenta during the fetal stage, and with the colostrum at the neonatal phase. Selenium, even at low concentration in the ewe's body, is efficiently passed on to the fetus **(Koller *et al.* 1984)**. Also, **Cuesta *et al.* (1995)** found that parenteral administration of Se significantly increases its concentrations in colostrum and milk.

DISCUSSION AND CONCLUSIONS

There are concerns over the safety of nanoparticles, but parameters measured in this study indicated that there was no effect on animal performance and health.

Selenium can be supplemented in animal diets in two forms: inorganic forms such as sodium selenite, or organic bounded forms such as selenomethionine, lactate-protein Se complex, Se-proteinate, Se-enriched yeast, and Se-enriched alga (**Faixová *et al.*, 2016, Kachuee *et al.*, 2019**). The organic forms of Se are safer and can be passed into milk (**Sun *et al.*, 2017, Ianni *et al.*, 2019**), but the inorganic Se is the most common form used in dairy animals as feed supplementations because of the higher rate of reaction than the organic Se sources.

Recently, significant effort has been devoted to enhancing the bioavailability of bio-organic materials. The nano-materials are effective biological pathways to offer a suitable means of delivering the bioactive components for ruminants (**Soltan *et al.*, 2021**). In this respect, producing bio-nanostructured selenium (SeNSM) is a new direction of the green chemistry used for enhancing the Se biological activity (**Malyugina *et al.*, 2021**). Products of SeNSM exhibit various vital functional properties (e.g., antioxidant, antimicrobial, and anti-inflammatory) therefore they were considered safe feed supplements for livestock (**Boroumand *et al.*, 2019 and Malyugina *et al.*, 2021**).

Recently, SeNSM was produced by yogurt culture containing *Streptococcus thermophiles* and *Lactobacillus delbrueckii subsp. bulgaricus* in a whey yeast extract media, and supplemented at 0.1 and 0.2 mg/ kg DM to late pregnant ewes had increased their lamb growth performance and immunological status throughout the lactation period (**Salam *et al.*, 2021**). Moreover, Se NSM enhanced the antioxidant status of dairy cows, in particular, the Sel gene expression in the mammary glands, which can enhance the animal's productive performance.

Adequate blood Se concentration plays an important role in maintaining the health of the mammary gland, while Se deficiency causes marked inflammation in the mammary gland tissues (**Davidov *et al.*, 2014**).

The recommended Se supplementation dose by FDA is 0.3 mg/ kg DM (**Morsy *et al.*, 2019**), which can be increased in cases where particular energy requirements are increased (e.g., early lactation), especially in countries that have soils deficient in Se like Egypt (**El-Shahat and Abdel Monem, 2011**) more studies reported that the super nutritional organic Se supplementation (more than 1 mg/ kg DM) was not only found to enhance lamb growth performance (**Mousaie *et al.*, 2014**) but also enhance the blood antioxidant status (**Shi *et al.*, 2018, Mousaie, 2021**). These findings provide a hypothesis that the dietary SeNSM may affect the milk yield and health status of dairy ewes

Nanoparticles define materials with a dimension generally between 1 and 100 nm (**Jiang *et al.*, 2008**), while, the term nanostructured materials describe materials made of a single material or multiple materials with at least one dimension in the nanoscale range (<100 nm), thus they may have larger sizes (up to 500 nm) than the nanoparticles (**Harish *et al.*, 2022**). The bio- nanostructured materials have unique features such as high surface activity, large specific surface area, and high catalytic.

CONCLUSION

In conclusion, the results of the current study indicated that both Se sources positively affected on reproductive performance of Zaraibi goats, without altering blood metabolite parameters. The treatment of organic nano- Se was more effective than sodium selenite in improving feed efficiency and kids' growth.

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The authors declare that they have no conflict of interest.

AUTHORS CONTRIBUTION:
All authors developed the concept of the manuscript, achieved the experiments ,and wrote and revised the final manuscript.

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الملخص العربى

تأثير السيلينيوم العضوى وغير العضوي على الأداء التناسلى للماعز الزرايبي

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استخدم 40 معزة زرايبي عمر 3 سنوات ووزن حي 41 كجم. تم تقسيم الماعز في خمس مجموعات معاملة مماثلة بناءً على عمرها ووزن الجسم (8 معزة / مجموعة) وتم تغذية المجموعة الضابطة على نظام غذائي أساسي يحتوي على 0.17 ملجم Se / كجم DM. غذيت الماعز المعاملة على نفس العليقة الأساسية مضافاً إليها المعاملة بـ Se كما يلي: المجموعة الأولى (G1): كمجموعة كنترول بدون أي معاملة. المجموعة الثانية (G2): تم حقن الماعز بجرعة 0.1 ملغ من السيلينيوم (سيلينيت الصوديوم) /كجم من وزن الجسم. المجموعة الثالثة (G3): تم حقن الماعز بجرعة 0.2 ملجم من السيلينيوم (سيلينيت الصوديوم) / كجم من وزن الجسم. المجموعة الرابعة (G4): جرعت الماعز (0.1 ملجم/كجم وزن الجسم) من النانو سيلينيوم. المجموعة الخامسة (G5): جرعت الماعز (0.2 ملجم/كجم وزن الجسم) من النانو سيلينيوم. كانت قيم النسبة المئوية لحدوث الشبق بعد المعاملة أعلى بكثير (P<0.05) في مجموعات G3 وG4 وG5 (100%) وانخفض النشاط الشبقى فى مجموعة (G2) (87.5%) مقارنة بالمجموعة الكنترول الذى حدث بها نشاط شبقي منخفض نسبيًا (٪75). كان عدد المواليد أعلى قيمة (2.25) لـG4 وG5 بينما انخفضت تدريجياً لتصل إلى 1.71 و1.66 لـG2 وG3 وأقل قيمة 1.16 لـG1 (الكنترول). وكانت نسبة التوائم في مجموعات المعاملة (G2، G3، G4 و G5) لديهم ولادة فردية بنسبة (16.7، 14.3، 12.5 و 12.5٪) مقارنة مع المجموعة G1 وبفروق معنوية أنتجت ولادة فردية أكثر (60٪). بينما كانت أعلى قيمة لولادة التوائم هي G2(66.7%) مع وجود فروق معنوية (P<0.05)، بينما كانت G3 وG4 و57.1% G5 و50% و50% مقارنة بأقل قيمة للتوائم (40%). للماعز الكنترول (G1). ومن الجدير بالذكر أن الماعز التى انتجت ثلاثى كانت 16.6 و 28.6 و 37.5 و 37.5% لـ G2 و G3 و G4 و G5. ، ماعدا المجموعة الخامسة أنجب عدداً أكبر من الإناث (61.1%) وعدد أقل من الذكور (38.9%) مقارنة بمجموعة المعاملة أو الكنترول الأخرى. وكانت القيم 42.9، 58.3، 40 و 55.5٪ ذكور لـ G1، G2، G3 و G4، على التوالي.

الكلمات المفتاحية: نانو سلينيوم ، السيلينيوم ، الماعز ، الأكسدة ، الخصوبة ، التناسل.