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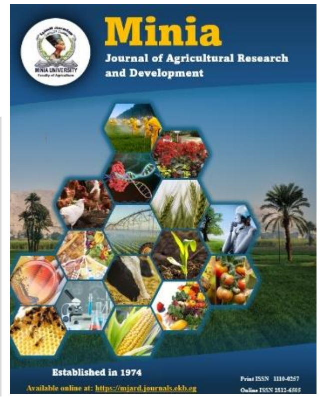

Sexual receptivity and performance traits of female rabbit's effectiveness by feed restriction regimen

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ABSTRACT

This study was done to determine the effect of feeding regimen for female rabbits on the productive, reproductive and physiological responses. Fourty-five V-line nulliparous female rabbits, average age 6 months and weighing an average of 2925.33±55.21 g in this study experimental was lasted for 1 parity. The first group was received 100% of recommended diet daily and served as a control (**C**), the 2nd (**G1**), was received 75% of recommended diet daily; the 3rd was received 100% of recommended diet daily for 2 days and fasting for 1 day (skip-a-day system) (G2). Results showed that rabbits in group G2 exhibited the highest body weight (2965 g), followed by group C (2950 g), and group G1 had the lowest body weight (2865 g). Group C (control) had the highest total feed consumption (8060 g), while G1 and G2 had significantly reduced total feed consumption (6070 and 5450 g, respectively). Data revealed that fertility rate was highest in group G1 (96.67%), followed by G2 (90.00%) and C (73.33%). These results suggest that both moderate feed restriction and intermittent fasting improved fertility compared to the control group. Litter weight at weaning was significantly higher in control group (3120 g) compared to G1 (2840 g) and G2 (2909 g). Interestingly, **G2** (intermittent fasting) showed a significant decrease in ALT levels (32.67) in compared with control group. While, AST values were relatively stable across all groups with no significant differences between **C, G1** and **G2 group**. The urea level in control group (C) was 37.67 and relatively high compared to the other groups. The creatinine value in the control group was 1.27, which is typical for healthy, non-stressed rabbits. There is no indication of kidney dysfunction or impaired filtration. **Feed restriction** in female rabbits showed the most beneficial effects on reproductive traits and liver, kidney function.

Key words: Body weight, fertility, feed restriction, female rabbits, liver and kidney functions.

INTRODUCTION

Rabbits have high reproductive potential since the females, in the suitable conditions, can produce five to nine litters per year and each litter contains about 5 to 8 kits **(Cheeke, 1987).**

Rabbit nutritionists are looking for developing estrategies capable of reducing digestive disorders and increasing feed

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efficiency, so lowering feeding and total production costs (**Maertens 2009**). The fertility and reproductive efficiency of female rabbits are significantly influenced by their body condition **(Cifre *et al.*, 1994; Fortun-Lamothe, 1997)**. Feed intake during the rearing period is a critical determinant of body development, which in turn impacts reproductive potential **(Rommers *et al.*, 1999)**. The interplay between nutrition and reproductive function is well-documented; nutritional status can modulate reproductive performance through multiple pathways, including central mechanisms affecting gonadotropin secretion **(Booth *et al.*, 1994)** and peripheral actions on ovarian activity **(Cosgrove and Foxcroft, 1996)**. According to **Eiben *et al.*, (2001)** and **Rommers *et al.*, (2001)**, implementing feed restriction during the rearing phase, followed by a brief flushing period and postponing the first insemination to an older age, appears to be a promising strategy for optimizing the body development of young female rabbits and enhancing both their productivity and longevity. Feed restriction is commonly employed in female rabbits to prevent excessive fat deposition, reduce reproductive complications, and improve overall reproductive performance **(Rommers *et al.*, 2004)**.

The objective of this study was to determine the effect feeding regimen for rabbit females to improvement of the productive, reproductive and physiological responses.

MATERIALS AND METHODS

This study was carried out at a private commercial rabbitary farm located in Minia government, Upper Egypt, during the period from December 2020 to March 2021. The aim of experiments was to study the effect of feed restriction (quantity or periodically) on some reproductive, productive and physiological responses of rabbit females.

Experimental design:

This experiment was designed to investigate the effect of feeding on three diet based on feed restriction as follows in Table 1.

Table 1. The design of the dietary treatments

Groups	Treatments
C	Rabbits fed 100% of recommended daily
G1	Rabbits fed 75% of recommended daily
G2	Rabbits fed 100% of recommended for 2 days followed by fasting for 1 day (Skip-a-day system)

C: Control group, G1: Group 1, G2: Group 2

All experimental diets were formulated to contain adequate levels of nutrients for V-line rabbits as recommended by the National Research Council, (**NRC, 2004)**. The chemical analysis of ingredients and diets were determined according to **AOAC (2006)**. The composition and chemical analysis of ingredients and diets were shown in **Table 2**.

Table 2. Composition and calculated analysis of the experimental diets

Ingredients%	%
Ground yellow corn	36.95
Soya bean meal (44%)	17.50
Alfalfa hay	25.00
Wheat bran	18.75
Lime stone	1.00
Salt	0.50
Premix*	0.30
Total	100
Calculated analysis%	
Digestible energy. (kcal / kg feed)	2436.76
Crude protein, %	19.7
Crude fiber, %	13.78
EE, %	3.73
Calcium, %	0.87
Available phosphorus, %	0.47
Methionine, %	0.79
Lysine, %	0.37

* Each 2.5 kg of the premixed vitamin and mineral supplement contained the following: 12,000,000 IU vitamin A acetate, 2,000,000 IU vitamin D_3, 10,000 mg vitamin E acetate, 2,000 mg vitamin K_3, 100 mg vitamin B_1, 4,000 mg vitamin B_2, 1,500 mg vitamin B_6, 10 mg vitamin B_{12}, 10,000 mg pantothenic acid, 20,000 mg nicotinic acid, 1,000 mg folic acid, 50 mg biotin, 500,000 mg choline chloride, 10,000 mg copper, 1,000 mg iodine, 300,000 mg iron, 55,000 mg manganese, 55,000 mg zinc, and 100 mg selenium.

Experimental animals:

A total number of 45 nullimiparous V-line rabbit females (6 months of age) were randomly distributed into (3 treatments×15 replicates×1 female = 45). All rabbits were housed in a semi-closed house within cleaned wire-floor battery cages. Each cage measured 45 × 45 × 38 cm (length × width × height, respectively) and was equipped with a sheet metal nest box for kindling.

The dimensions of the nests were (35×25×25 cm) for length, width and height, respectively. All females were distributed into three dietary treatment groups and fed the same dietary as described in Table 1. All females were housed indor 14 hours' light/day during the experimental period. Free drinking water was avaliable throughout nipples (automatic drinkers) during the experimental period. The air temperature, relative humidity and temperature-humidity index inside the building during the time of the experiment were measured daily at 6 am and 6 pm. Ambient air temperature ranged from 15 to 34 °C, while relative humidity varied between 19% and 35%. The temperature-humidity index (THI) ranged from 18 to 33 and was calculated using the following equation:

$$THI = db°C - [(0.31 - 0.31 \times RH\ \%) \times (db°C - 14.4)],$$

Where, **db°C** represents the dry-bulb temperature in degrees Celsius, and **RH** denotes the relative humidity expressed as a percentage. The calculated THI values were classified according to Marai et al. (2001) as follows: absence of heat stress (<27.8), moderate heat stress (27.8–28.8), severe heat stress (28.9–29.9), and very severe heat stress (≥30.0).

Productive performance parameters:

Live body weight and body weight gain of females were recorded to the nearest gram. At the first day of the experiment before the begging of fasting, after two weeks of feeding (before mating), after 25 days of pregnancy, after birth and after 28 days of suckling. Changes in live body weight during pregnancy, the changes in live body weight at first service, the changes in live body weight during suckling period and female weight (g) at 28 day of suckling, body weight gain was calculated by subtracting the average initial live weight from the average final live weight for the same period. All weight measurements were taken at the beginning of the experiment before the morning feeding (06:00 h). The females in each replicate was provided with a certain amount of feed before two weeks from mating, after 25 days from mating feed consumption from 26 days of mating day until birth, total feed consumption, daily feed consumption were recorded. The remainder and scattered of feed as were record each, then the feed consumption was calculated by difference for females/day during the experimental periods. All males which used in the artificial insemination were feed control diet during all ages. Also, males were in the same age of females. The semen was collected from bucks by artificial vagina which consists of a rubber tube surrounded by another tube containing warm water at a temperature of about 38-40°C inner surface of the vagina has a thin-walled rubber lining**.** Initially, the buck is permitted to mate with a teaser female. As the buck reaches ejaculation, the penis is positioned into an artificial vagina, where the semen is collected. The fresh semen is assessed immediately on the farm after collection. The primary purpose of extending (or diluting) the semen is to enhance the number of females that can be inseminated from a single ejaculate. A typical ejaculate from a buck can be utilized to inseminate 5 to 10 females if fully extended. This is created using egg yolk. A suitable extender not only increases the volume of the ejaculate but also promotes the survival and longevity of sperm. The dilution rate is contingent on the quality of sperm per insemination, contributing to favorable conception rates. Antibiotics like penicillin and streptomycin are included in semen extenders. These antibiotics help prevent bacterial growth and minimize the risk of transmitting diseases such as vibriosis. The females were inseminated with 0.5 ml fresh diluted semen of a commercial diluent in upper part of vagina and 0.2 ml of Resptal was used as GnRH (Gonadotropin-releasing hormone) analogue intramuscularly at the moment of insemination. Each female was palpated at 14 days after insemination, thereafter to detect pregnancy. Females which failed to conceive were returned to mating by artificial insemination at the day 18^{th} of last insemination accoding to **El-Sawy *et al.*, (2010)**. The number of mating computation, fertility% and pregnancy length were recorded. Rabbits in all treatment groups were kept under similar managerial system and environmental conditions. Kindling rate, litter size, died letter size at birth, bunny weight at weaning, and weight at birth values were recorded. Pre-weaning mortality rates, letter weight at weaning and letter size at weaning per female were recorded.

Blood samples was taken from the marginal ear vein at the morning and after daily nursing from five females per group during the period of the experiment before the begging of fasting, after two weeks of feeding (before mating) and after 25 days of pregnancy. Five samples were collected from each treatment into centrifuge tubes. Each blood sample was split into two sections. The first section was put in tubes containing ethylene diaminetetraacetic acid (EDTA) for hematological assessments. The second section was placed in a tube for serum separation to assess biochemical parameters. The samples were spun immediately at 3000 rpm for 15 minutes, and the serum was collected and preserved at -20°C in Eppendorf tubes until analysis. Meanwhile, the samples intended for serum immunity measurements were kept at -80°C in Eppendorf tubes until they were analyzed. Serum samples were analyzed for serum keney functions urea, (**Archibald *et al.*, 1945** and creatinine, **Heinegård and Tiderström, 1973**). Liver fuction also determined.

Statistical analysis:

Statistical analysis was carried out using a general linear model (GLM) of the **SAS (2001)** program. The effects of treatments on all parametrs studied were evaluated by one-way ANOVA. The significant differences between treatment means were tested by Duncan Multiple Range Test (**Steel and Torrie, 1980**). The data are presented as means and MSE. Probability values of less than 0.05 ($P \leq 0.05$) were considered to be significant. Statistical analysis using the following model:

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

Where:

Y_{ij} = Experiment observations,

μ = The overall mean,

T_i= The effect of dietary treatment,

i= T1, ----- T3, and

e_{ij} = The experimental error.

Duncan's test was used to examine the significance degrees among means **(Duncan, 1955).**

RESULTS AND DISCUSSION

Body weight and body weight changes (g) of females:

The body weight (BW) of animals, including female rabbits, is an important physiological parameter that can reflect nutritional status, metabolic efficiency, and overall health. The effects of feed restriction on the body weight and body weight changes (BW changes, in grams) in females depend on the severity and type of restriction. In the given dataset, there are multiple body weight parameters, including the initial body weight at the start of the study, body weight at various time points, and weight changes over different periods. At the beginning of the study, the body weights of the females were relatively similar across all groups, in middle of the study, group C showed an increase in body weight (3016 g), while groups G1 and G2 showed smaller increases (2933 and 2909 g, respectively). This suggests that moderate feed restriction (G1) and intermittent fasting (skip-a-day system) (G2) resulted in less weight gain compared to the control group, as expected due to reduced energy intake in these groups. At 25 days, the body weights across all groups were quite similar, with group C at 3159.00 g, group G1 at 3141.33 g, and group G2 at 3153.33 g. This indicates that despite feed restriction or fasting, the females in all groups managed to maintain similar body weights by the end of the study period. The slight difference in body weight change across the groups is not statistically significant, which may suggest that rabbits in all groups adapted to their respective feeding conditions. At the end of the study, group G2 exhibited the highest body weight (2965 g), followed by group C (2950 g), and group G1 had the lowest body weight (2865 g). This suggests that intermittent fasting (Group G2) might have allowed for a recovery in body weight, potentially due to compensatory feeding or metabolic adjustments after the fasting phase. On the other hand, the moderate feed restriction in group G1 resulted in the lowest final body weight, as expected due to prolonged caloric restriction. The average body weight over the study period shows that group G1 had the highest average body weight (3093.80 g), followed by group G2 (3008.80 g), and group C had the lowest average body weight (2987.22 g), this reflects the overall effect of feeding treatment on body weight. The higher average body weight in group G1 could be due to the fact that the moderate restriction did not lead to significant weight loss during the study and might have induced compensatory weight gain during periods of unrestricted feeding.

Feed restriction typically leads to a reduction in body weight because of reduced caloric intake. However, compensatory growth can occur after the period of restriction if feed intake is restored (**Yamauchi *et al.*, 2017**). **Longo *et al.*, (2016**) showing that intermittent fasting can stimulate metabolic adaptations, including improved nutrient utilization and weight management during refeeding periods. **El-Kamhawy (2014)** reported that rabbits on a restricted diet of 15% of *ad libitum* intake from 12 to 24 weeks of age exhibited significantly ($P<0.001$) higher body weights at various ages measured, followed by those on *ad libitum* diets, while the lowest body weight was observed in the group of rabbits that received a restricted diet of 25%. The author also noted that the 25% diet restriction led to a decrease in body weight by 6.35%, 11.15%, and 12.01% at 16, 20, and 24 weeks of age, respectively, when compared to the rabbits fed *ad libitum*. **Abou Sekken (2005)** found that fasted rabbit two day every week during rearing period decreased body weight compared with that fed ad libitum. He also showed that restrictively fed females inseminated at 20 wk of age had body weights similar to that fed *ad libitum* and inseminated at 20 wk of age.

Similar findings were reported by **Rommers (2001), Chiericato *et al.* (2001), Fekete *et al.* (2001), Fodor *et al.* (2003),** and **Gyovai *et al.* (2003),** who indicated that restricted feeding can be employed to manage body growth and limit excessive fat accumulation in female rabbits. In contrast, **Bonanno *et al.* (2004)** discovered that restricting feed to 75% from 11 weeks of age until 10 days before the first artificial insemination resulted in a lower growth rate compared to ad libitum (23.1 vs. 35.4 g/d; $P<0.0001$) but led to a greater body weight at the time of artificial insemination (3571 vs. 3427 g, $P<0.002$) in NZW female rabbits.

El-Kamhawy (2014) noted that rabbits fed restricted 15% diet had significantly increased daily body weight gain by 8.16, 2.01 and 3.57 % during 12-16, 16-20 and 20-24 weeks of ages, respectively compared to that fed ad libitum. However, the lowest daily body weight was recorded for rabbit group fed 25% restricted. On the other hand, increasing restriction rate from 15 to 25 % restriction significant decreased daily body weight gain by 23.4, 28.91and 17.36%, respectively, compared with that fed ad libitum and by 28.85, 30.29 and 20.21 compared with those fed 15% restricted diets during 12-16,16-20 and 20-24weeks of ages. The reduction in daily body weight gain at the highest rate corresponded with findings from **Tawfeek (1996)**, who reported that the daily weight gains of New Zealand White rabbits at 10 and 12 weeks was significantly lower ($P<0.05$) in the group with restricted feeding (80% of ad libitum intake from 5-12 weeks of age) compared to those with ad libitum feeding. **Chiericato *et al.* (2001)** also indicated that feed restriction had a negative impact ($P<0.01$) on body weight gain (1.07 vs.

33.10 g/day) in restricted-fed female rabbits (receiving 80 g/day, which is about 50% of ad libitum intake) during the prepubertal stage. Furthermore, **Fekete *et al.* (2001)** discovered that the average daily gains of female New Zealand White rabbits (6-18 weeks old) was significantly less in the 70% restricted group than in those on an ad libitum feeding regimen (25.5±5.6 vs. 32.4±3.2 g).

Table 3. Effect of feed restriction on body weight and body weight changes (g) of females

Traits	Treatments			MSE	P-Value
	C	G1	G2		
BWBF	2951	2862	2963	55.21	0.3719
BWBM	3016	2933	2909	59.54	0.4169
BWA25	3159.00	3141.33	3153.33	67.93	0.9825
BWAB	2950	2865	2965	75.00	0.6053
CLBWDP	142.67	208.00	244.33	49.20	0.3435
AVW	2987.22	3093.80	3008.80	37.52	0.1287
TFC	8060^{a}	6070^{b}	5450^{c}	20.00	<.0001
DFC	268.60^{a}	202.47^{b}	181.68^{c}	0.70	<.0001

[a,b,c] means with the same letter are not significant in the same row. MSE: Mean-standard error. C: Rabbits fed basal diet 100%, G1: Rabbits fed 0.75 of basal diet daily, G2: Rabbits fed basal diet 100% for 2 days and fasting for 1 day (skip-a-day system). BWBF: body weight before fasting, BWBM: body weight before mating, BWA25: body weight after 25 days of pregnancy, BWAB: body weight after birth, CLBWDP**:** changes in live body weight during pregnancy, AVW: female weight (g) at 28 day of suckling, TFC: total feed consumption and DFC: daily feed consumption.

The total feed consumption (TFC) over the study period followed the same trend. Group C (control) had the highest total feed consumption (8060 g), while G1 and G2 had significantly reduced total feed consumption (6070 and 5450 g, respectively). This difference in TFC highlights the cumulative effect of feed restriction and intermittent fasting on overall feed consumption. The lower intake in G1 and G2 can be attributed to the energy limitations imposed by the dietary treatments, affecting the total amount of feed consumed during the study (**Gallaher *et al.*, 2014**).

Daily feed consumption (DFC) followed the same pattern as the total consumption. Group C had the highest DFC (268.60 g), while G1 (202.47 g) and G2 (181.68 g) had significantly lower DFC. This supports the hypothesis that moderate feed restriction (G1) and intermittent fasting (G2) both led to reduced daily feed consumption. The daily intake reduction in G1 and G2 is likely due to both metabolic adaptation and the physiological responses to restricted feeding periods according to **Juszczuk-Kubiak *et al.*, (2017**). **Pérez *et al.*, (2014**) stated that prolonged feed restriction may reduce the appetite due to metabolic adaptation. **Sutton *et al.*, (2018**) reported that lowest feed intake and appetitr suppression during the refeeding period after fasting might be due to the body adjusting to fasting periods, which can affect food intake during the refeeding phase. Both feed restriction treatments result in a significant decrease in feed intake when compared to ad libitum feeding, which is a common finding in studies involving caloric restriction or fasting in animals (**Brouns *et al.*, 2017**).

El-Kamhawy (2014) demonstrated that the feeding regimen had a significant impact (P<0.001) on feed intake during the various periods examined. No notable differences were found between the rabbits that were given access to food ad libitum and those whose daily feed intake was restricted by 15% during the time frames of 12-16, 16-20, and 20-24 weeks of age. Conversely, **Eiben *et al. (*2001)** reported that in the first week of treatment, feed intake saw a dramatic decline of 12% in the group subjected to one day of fasting per week compared to the control group, and the daily feed intake in the fasting group was 5% lower between 10 and 17 weeks of age than that of the control group. However, rabbits with a 25% feed restriction consumed significantly less feed by 22.95%, 28.89%, and 17.36% during the periods of 12-16, 16-20, and 20-24 weeks of age, respectively, in comparison to those fed *ad libitum* **(El-Kamhawy, 2014)**.

The same pattern was reported by **Chiericato *et al*., (2001)** who indicated that limiting feed affected feed intake negatively (P<0.01) in female rabbits (consuming 80 g/day, roughly 50% of ad libitum intake) during their prepuberty phase. In contrast, **Klindt *et al*., (2001)** discovered that a moderate feed restriction (74% of ad libitum intake) decreased the amount of feed consumed from 13 weeks of age until the conclusion of the first pregnancy, without having a significant effect on piglet production efficiency. Rabbits on a restricted diet and those fasted for one day each week averaged 77.15% and 98.83% of the ad libitum diet intake, respectively. This accounts for the lower body weight observed in rabbits subjected to the restricted diet, which may be linked to the diminished intake of crude protein, as protein is a crucial nutrient for growth and for the synthesis of enzymes and hormones that oversee metabolism, immunity, hemoproteins, glycoproteins, and lipoproteins **(Murray *et al.*, 1991).**

Some reproductive metrics of females:

Data in Table 4 revealed that fertility rate was highest in group G1 (96.67%), followed by G2 (90.00%) and C (73.33%). These results suggest that both moderate feed restriction and intermittent fasting improved fertility compared to the control group. The improvement of fertility in G1 and G2 may be linked to metabolic adaptations that enhance reproductive function, as animals under mild caloric restriction or intermittent fasting may experience hormonal shifts that optimize reproductive performance (**Duran-Montgé *et al.,* 2011**). This has been observed in several studies where limited feed intake during specific reproductive periods led to improved ovulation and conception rates in some species (**Pérez *et al*., 2014**).

Bunny weight at weaning was highest in the control group (670.01 g), followed by G2 (646.47 g), and G1 (611.10 g). This suggests that both feed restriction strategies resulted in smaller offspring at weaning. Reduced nutrient intake during gestation and lactation can limit growth potential, leading to lower body weights in the offspring (**Calderon *et al.,* 2018**). However, G2 (intermittent fasting) resulted in less weight reduction than G1 (moderate restriction), possibly due to the compensatory feeding effect observed in intermittent fasting where the females may have adapted to their feeding schedule by maximizing nutrient intake during feeding periods (**Longo *et al.,* 2016**).

Litter size at birth was slightly reduced in G1 and G2 compared to C, with G2 showing the lowest litter size (LLSB: 5.47, TLSB: 5.67). This decrease could be a result of the caloric restriction or fasting periods, which may impair the ability to support optimal fetal growth and survival (**Xia *et al.,* 2016**). While the differences were not large, the trend shows that caloric restriction, particularly intermittent fasting, can slightly reduce litter size at birth.

Litter weight at birth was highest in G2 (300.33 g), followed by C (284.09 g) and G1 (269.67 g). Interestingly, G2, despite the intermittent fasting regime, had a higher litter weight at birth compared to G1, indicating that intermittent fasting might be less detrimental to offspring weight than continuous feed restriction. This could be due to metabolic adaptations during refeeding periods, which might support fetal growth better than constant feed restriction (**Longo *et al.*, 2016**).

Body weight at birth followed a similar trend as litter weight, with G2 having the highest weight (53.63 g), followed by C (51.62 g), and G1 having the lowest (47.48 g). This suggests that intermittent fasting may have a more favorable effect on offspring birth weight compared to continuous feed restriction (**Calderon *et al.*, 2018**).

Litter weight at weaning was significantly higher in Group C (3120 g) compared to G1 (2840 g) and G2 (2909 g). This supports the idea that reduced feed intake, whether through continuous restriction or intermittent fasting, leads to lower weaning weights. Offspring in restricted feeding groups likely experience slower growth due to less optimal nutrition during lactation (**Pérez *et al.*, 2014**).

The litter size at weaning was highest in G1 (5.08) and lowest in G2 (4.80), with C showing an intermediate result (4.89). While feed restriction may reduce the number of surviving kits at weaning, G1 had a slight increase compared to C, possibly due to improved metabolic adaptation to moderate caloric restriction (**Duran-Montgé *et al.*, 2011**).

The findings of the current study align with those of **El-Kamhawy (2014),** who reported that the kindling rate for females on restricted R15% and R25% feeding regimens improved to 88.5% and 82.3%, respectively, in comparison to those fed ad libitum, which had a rate of 72.45%. **Tribble and Orr (1982)** noted that implementing controlled feed restriction can enhance conception rates. **Abou Sekken (2005)** also observed that feed restriction systems had a significant ($P<0.05$) impact on the conception rates of female rabbits. Conversely, **Eiben *et al.*, (1999)** found that groups subjected to various levels of feed restriction (document_number_1), which included a restricted daily feed portion from 10 to 17 weeks of age and a daily intake of 140 g until the first breeding, showed an improvement in conception rates by 5 to 9% compared to the control group (62%). Furthermore**, Khalifa (2006)** noted that the conception rate of New Zealand White rabbit females increased when a prolonged feeding schedule was utilized (where females received 65% of ad libitum for 50 days prior to the first insemination). Eiben et al. (2001) discovered that fertility in nulliparous females who experienced a single day of fasting each week from 10 to 17 weeks of age was significantly higher (92%) than that in the control group (70%). This same tendency was found by **Gosalvez *et al*. (1994),** who indicated that feed restriction positively influenced the quantity of preovulatory follicles and improved their breakage, leading to a greater ovulation rate. They suggested that the enhanced fertility could be attributed to the older breeding age of the restricted females and the beneficial impact of flushing on the ovulation process. **Mahmoud *et al.*, (2006)** reported a non significant difference between the number of rabbit's oocytes/ ovary fed 60% of control for one or two months. **Niveen *et al.*, (2012)** who recorded that the percentage of mature oocyte was significantly increased in feed restricted groups and after refeeding compared to control group, while immature oocytes were significantly decreased. The previous results can be explained by the evidence that, alterednutritional regimes prior to mating can influence follicular/oocyte characteristics without alteringgonadotrophin secretion per second

Armstrong *et al*., (2001). On the opposite trend, **Maertens (1995)** observed that the conception rate of New Zealand White rabbits at their 1st breeding season was lower in restricted fed rabbits than that fed *ad libitum*.

Litter size at birth, 21 and 28 days (weaning) was significantly higher in females fed restricted regime R 15% and R 25% than in the *ad libitum* feeding regime **(El-Kamhawy, 2014)**. Restrictively females during rearing period had significantly highest litter weight at birth, 21 and 28 days and fed *ad libitum* feeding regime were recorded the same trend females **(El-Kamhawy, 2014)**.

The current findings align with those presented by **Bonanno *et al.* (2004),** who discovered that feeding restrictions (75% of ad libitum until 10 days prior to the first artificial insemination, conducted at 19.5 weeks of age) had no impact on the kindling rate; however, the litter size at birth increased by 0.7 kits in the R19.5 group, which also exhibited a tendency for greater productivity concerning the number and weight of weaned rabbits compared to females that were fed ad libitum and inseminated at 16.5 weeks of age. Furthermore**, Rommers (2001)** noted that females receiving restricted feeding and inseminated at 17.5 weeks of age had a higher number of live-born kits, weaned more kits, and resulted in greater litter weight at 16 days of lactation in their first parity when compared to females fed ad libitum and inseminated at the same age. In contrast, Wittorff et al. (1988) found that feed restriction influenced litter weight, litter size at birth, and growth rate of kits. **Manchisi *et al.* (1990)** also indicated that a restricted feeding regimen (140 g daily, approximately 80% of ad libitum) led to a significant increase in the number of offspring born in nulliparous New Zealand White rabbits. Moreover, Rommers et al. (2004b) reported that females with restricted feeding and inseminated at 17.5 weeks produced more live-born kits (+1.4) and weaned more kits (+0.6) in their first parity compared to females fed ad libitum, whether inseminated at 14.5 or 17.5 weeks. Additionally, Kemp et al. (2004) found that the litter size of rabbits at weaning was enhanced by restricted feeding during the rearing period. Based on data from females fed ad libitum and inseminated at 14.5 weeks of age (Rommers et al., 2002), a positive correlation was observed between body weight at 14.5 weeks and litter size in the first parity. The litter size increased from 6.4 to 8.9 kits for females weighing under 3.5 kg compared to those over 4 kg at the initial insemination. Hartmann and Petersen (1995) also found that feed restriction during the rearing period was linked to an increase in litter size at birth after the first parity for multiparous rabbits. **Rommers *et al*. (2004b)** indicated that the most productive outcomes were observed in R17.5 females, likely because they had better feed intake during lactation (in contrast to AL17.5 females) and prioritized body growth less (compared to AL14.5 females). Additionally, **Rommers (2004)** noted that apart from enhancing body weight uniformity and thus improving litter size, restrictive feeding during the rearing period led to better milk production and increased weaning weights of the kits at the termination of the first lactation. However, **Abou Sekken (2005)** found that feed restriction systems did not significantly influence litter size at birth, nor at 21 and 30 days of age, but litter weight was significantly ($P<0.05$) highest in the 130 R group (receiving 130 g of restricted feed daily until 17 weeks of age, followed by 140 g/day until the first mating), while the groups subjected to two days of fasting per week and limited six-hour daily access to the diet produced the lowest litter weight at 21 and 30 days of age. **Khalifa (2006)** noted that both litter size and birth or weaning weight significantly improved in the short feeding program (SFP) group, which received 65% of the ad libitum diet for 15 days prior to the first insemination, compared to the ad libitum group. A study conducted in Hungary by **Eiben *et al.* (2001)** observed that litter size at birth, and at 21 and 35 days of age, in groups receiving a daily feed allowance of 130 g per head until 17 weeks of age (130R; 8.8, 7.6, 7.3) and those with 9 hours of daily access to the feed (9H; 8.9, 8.3, 8.2), were not significantly different in litter weights, with 130R (502 g, 2760 g, 6295 g) and 9H females (543 g, 2848 g, 6761 g) showing weights that were not substantially greater than the control group (8.7, 7.3, 7.0 and 472 g, 2451 g, and 6032 g, respectively). He added that the low litter size and weight of 1D females could be linked to their overall smaller body weight throughout the study. Furthermore, **Tawfeek (1996)** found no significant differences in litter size at birth and litter weight in New Zealand White rabbits between the restricted and ad libitum feeding groups, although the litter weights at 21 and 30 days of age (weaning age) were significantly lower ($P<0.05$) with the restricted diet. Eiben et al. (1999) reported that there were no significant increases in litter size or litter weight at birth, on the 21st day, and at weaning for the 130R group (8.5 and 514 g, 7.6 and 2726 g, 7.3 and 6296 g) and the 9H group (8.6 and 499 g, 7.7 and 2624 g, 7.7 and 6542 g) compared to the control group (8.4 and 461 g, 7.1 and 2444 g, and 6.9 and 6029 g).

Liver functions of females:

Alanine transaminase (ALT) is an enzyme found predominantly in the liver, and its levels are typically elevated when there is liver damage or inflammation. However, ALT levels in the current study did not show significant differences between the control group (C) and the moderate feed restriction group (G1), indicating that moderate feed restriction may not have a strong immediate impact on liver function as measured by ALT levels (Table 5).

Interestingly, G2 (intermittent fasting) showed a significant decrease in ALT levels (32.67), suggesting that the liver may be undergoing some adaptive response to intermittent fasting. It is possible that intermittent fasting induces mild metabolic stress, leading to a transient reduction in liver enzyme activity, which could be due to the body's adaptation mechanisms to nutrient scarcity (**Longo *et al.*, 2016**). This might be indicative of lower liver turnover or a reduction in liver metabolic activity during fasting phases.

Aspartate aminotransferase (AST) is another enzyme found in the liver but also in other tissues, such as muscle. AST levels, similar to ALT, can rise with liver damage but can also be influenced by other organs. In this study, AST values were relatively stable across all groups, with no significant differences between C**,** G1, and G2. This suggests that feed restriction, whether moderate or intermittent, females not lead to major liver damage that would cause elevated AST levels. The stable AST levels indicate that while feed restriction might affect the liver's metabolic processes, in females not appear to cause significant liver damage in the short term.

The ALT/AST ratio is often used as an indicator of liver health. Typically, a lower ALT/AST ratio may indicate liver injury or a shift in metabolic processes. In this case, G2 exhibited a significantly lower ALT/AST ratio (1.25), which could suggest a shift in liver metabolism or function due to intermittent fasting. The reduced ratio might reflect an adaptive mechanism where the liver adjusts its enzyme production in response to feeding cycles, possibly indicating a phase of reduced hepatic stress or a transition into a more efficient metabolic state **(Kahl, 2014).** In contrast, the ALT/AST ratios in the control group (1.50) and G1 (1.48) were not significantly different, suggesting no major alteration in liver function due to moderate feed restriction.

Table 4. Effect of feed restriction on some reproductive metrics of females

Traits	Treatments			MSE	P-Value
	C	G1	G2		
Fertility	73.33[b]	96.67[a]	90.00[ab]	6.63	0.0471
BWW	670.01	611.10	646.47	36.16	0.5578
LLSB	5.82	5.53	5.47	0.51	0.8991
TLSB	6.09	6.00	5.67	0.54	0.8575
LWB	284.09	269.67	300.33	25.49	0.6985
BWB	51.62	47.48	53.63	3.91	0.5166
LWW	3120	2840	2909	262.02	0.8107
LSW	4.89	5.08	4.80	0.62	0.9465

[a,b,c] means with the same letter are not significant in the same row. MSE: Mean-standard error. C: Rabbits fed basal diet 100%, G1: Rabbits fed 0.75 of basal diet daily, G2: Rabbits fed basal diet 100% for 2 days and fasting for 1 day (skip-a-day system). BWW: bunny weight at weaning, LLSB: live letter size at birth, TLSB: total letter size at birth, LWB: letter weight at birth, BWB: body weight at birth, LWW: letter weight at weaning, LSW: letter size at weaning.

Table 5. Effect of feed restriction on liver functions of females

Traits / Treatments	ALT	AST	ALT/ AST Ratio
C	37.00[a]	25.00	1.50[a]
G1	36.00[a]	25.55	1.48[a]
G2	32.67[b]	26.00	1.25[b]
MSE	0.90	0.63	0.06
P-Value	0.004	0.433	0.008

[a,b,c] means with the same letter are not significant in the same row. MSE: Mean-standard error. C: Rabbits fed basal diet 100%, G1: Rabbits fed 0.75 of basal diet daily, G2: Rabbits fed basal diet 100% for 2 days and fasting for 1 day (skip-a-day system). MSE: Mean-standard error. ALT: alanine transaminase test, AST: aspartate transaminase test, ALT/ASTratio: alanine transaminase test /aspartate transaminase test ratio.

Kidney functions of females:

Urea is a waste product of protein metabolism and is filtered out by the kidneys. Its concentration in the blood can reflect kidney filtration efficiency, as well as hydration and protein breakdown.

Group C (Control): The urea level of 37.67 is relatively high compared to the other groups. This could indicate normal protein metabolism and kidney function, as the control group is fed a balanced diet without any restrictions.

Group G1 (75% of basal diet): A significant reduction in urea (31.67) was observed. This could suggest that the feed restriction leads to reduced protein intake or metabolic changes that lower urea production. A reduced protein intake would result in lower nitrogenous waste products like urea being produced, indicating a potential reduction in the kidney's filtration load. This is supported by findings that caloric restriction and reduced protein intake can result in lower blood urea nitrogen levels **(Redman *et al.*, 2009).**

Group G2 (Intermittent fasting): The urea level in this group (40.67) was higher than in G1, suggesting that intermittent fasting (2 days of feeding and 1 day of fasting) may result in altered protein metabolism or renal function. During fasting, the body might shift to utilizing stored proteins for energy, which could lead to higher urea production. This might reflect a temporary increase in renal workload, as protein catabolism increases during fasting (**Mehta *et al.*, 2018**).

Creatinine is another key biomarker for kidney function. It is a byproduct of muscle metabolism, and its blood concentration remains relatively stable, providing an indication of renal excretion. An increase in creatinine levels typically suggests impaired kidney filtration.

Group C (Control): The creatinine value in the control group is 1.27, which is typical for healthy, non-stressed rabbits. There is no indication of kidney dysfunction or impaired filtration.

Group G1 (75% of basal diet): The creatinine level in G1 (1.08) was significantly lower than in the control group, suggesting that the reduced feed intake might have decreased muscle mass or altered creatine turnover, leading to lower creatinine levels. Reduced feed intake can decrease muscle activity, potentially leading to a decrease in creatinine production, which reflects a reduced metabolic load on the kidneys (**Matsuda *et al.*, 2017**).

Group G2 (Intermittent fasting): Similar to Group C, G2 showed a creatinine level of 1.27, indicating that intermittent fasting did not significantly affect creatinine levels. This suggests that despite the intermittent fasting schedule, muscle metabolism and kidney function were not significantly altered in terms of creatinine excretion. This is consistent with findings that suggest short-term fasting may not dramatically affect muscle breakdown or kidney function (**Mettler *et al.*, 2015**).

Table 6. Effect of feed restriction on kidney functions of females

Treatments \ Traits	Urea	Crea
C	37.67[b]	1.27[a]
G1	31.67[c]	1.08[b]
G2	40.67[a]	1.27[a]
MSE	0.78	0.01
P-Value	<.0001	<.0001

[a,b,c] means with the same letter are not significant in the same row. MSE: Mean-standard error. C: Rabbits fed basal diet 100%, G1: Rabbits fed 0.75 of basal diet daily, G2: Rabbits fed basal diet 100% for 2 days and fasting for 1 day (skip-a-day system). MSE: Mean-standard error. Crea: caeatinine.

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الملخص العربي

لاستجابة التناسلية والإنتاجية لإناث الأرانب من خلال نظام تحديد التغذية

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تم إجراء هذه الدراسة لمعرفة تأثير نظام تحديد التغذية على اناث الأرانب من حيث الاستجابات الإنتاجية والتناسلية والفسيولوجية. وشملت الدراسة 45 أنثى من سلالة V-line بعمر 6 أشهر ومتوسط وزن 2925.33±55.21 جم، واستمرت التجربة حتى الحصول على أول بطن وقد تم توزيعها في ثلاثة مجموعات على النحو التالي:

1. المجموعة الضابطة (الكنترول) :(C) تلقت 100% من الغذاء الموصى به يوميًا.
2. المجموعة الأولى :(G1) تلقت 75% من الغذاء الموصي به يوميًا.
3. المجموعة الثانية :(G2) تلقت 100% من الغذاء الموصى به لمدة يومين ثم يوم صيام (نظام تخطي اليوم الواحد).

وكانت النتائج كالتالي:

- لم يكن هناك فرق معنوي في تغيّر الوزن بين المجموعات.
- وزن الجسم النهائي: كان الأعلى في المجموعة الثانية G2 (2965جم) ثم مجموعة الكنترول C 2950(جم) ثم في المجموعة الأولى G1 (2865جم).
- كان استهلاك الغذاء: كان الأعلى في الكنترول C (8060جم) مقارنة بالمجموعتين G1(6070 جم) وG2 (5450جم) .
- معدل الخصوبة: كان الأعلى في G1 (96.67%) .ثم G2 (90.00%) مقارنة بمجموعة .C (73.33%)
- وزن الخلفة عند الفطام: كان الأعلى في C (3120 جم) مقارنة بمجموعتي تحديد الغذاء G1 (2840 جم) و G2 (2909جم) .
- بالنسبة للمؤشرات الفسيولوجية أظهرت النتائج:
  - انخفاض ملحوظ في الانزيم الكبدي ALTفي.G2 (32.67)
  - استقرار مستويات الانزيم الكبدي AST بين المجموعات.
  - ارتفاع مستوى اليوريا في المجموعة الثانية (40.67) جاءت بعدها مجموعة الكنترول C (37.67) ثم المجموعة الاولىG1 (31.67) .
  - مستوى الكرياتينين كان طبيعيًا في جميع المعاملات مما يشير إلى عدم وجود مشاكل في الكلى.

تشير النتائج إلى أن تقليل التغذية بشكل معتدل أو الصيام المتقطع يُحسن الخصوبة مقارنة بمجموعة الكنترول.