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Impact of Water Restriction on the Productive and Behavioral Performance of Two Fattening Rabbit Breeds

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Abstract: The effects of water restriction (WR) on the growth performance, behavior, carcass and blood parameters of weaned rabbits were evaluated. The breed effects on these parameters were also assessed. Sixty rabbits of 35 days age of two breeds, 30 Alexandria (Alex) and 30 New-Zealand white (NZW) were used. Each breed was randomly divided into three equal groups. The control group (free access) was supplemented with free access of water (24 h/ day). Groups 2 and 3 of each breed received water for 2h/ day and 3 h/ day, respectively. The WR not significantly affect body weight, daily weight gain and relative growth rate, while it significantly reduced water and feed intake and improved the feed conversion ratio in comparison with control groups. The results also revealed that, WR had no significant effect on most of carcass parameters except for reducing the abdominal fat percentages. The hematological results showed that, a free access group of Alex rabbits had higher means for RBCs, HCT, MCV, lymphocytes and blood platelets; while, it was recorded the lowest values for MCH, MCHC, WBCs and granulocytes. The WR significantly affects some behavior performance of weaned rabbits (ceacotrophy, drinking time and some of exploratory behavior). Breed effect was clear for daily water consumption, feed conversion ratio, spleen percentage, ceacotrophy, walking time and some hematological parameters (MCH, MCHC, WBCs, lymphocytes, granulocytes and blood platelets). In conclusion, application of WR regimes (2 h and 3 h /day) has beneficial and economic effects on performance of fattening rabbit.

Key words: Rabbits · Breed · Water Restriction · Growth · Behavior · Blood

INTRODUCTION

Water intake is an important component of animal nutrition as it is a crucial constituent of body metabolism and temperature control [1]. Rabbits exhibit a comparatively high-water intake [2]. Factors that influence water intake are age [2], breed [3], environmental temperature [4], lactation [5], husbandry conditions [6], water restriction [7] and diseases [8]. Furthermore, water intake affected by dry matter intake (DMI) and food composition. The water facilitates several chemical reactions in the body, it acts as a medium and universal solvent in almost all vital body processes like digestion, absorption, intermediary metabolism, excretion and even in reproduction. About 60-70% of the total body weight of an animal is comprised of water, which is second only to oxygen in importance for the maintenance of life [9]. Water intake correlates linearly with DMI [2]. Therefore, water restriction (WR) used as an indirect factor for the feed restriction as WR most effective and easy to be applied [10, 11]. In fattening rabbits, feed Restriction (FR) was used as a strategy to reduce production costs, control digestive troubles and improved feed conversion [12, 13].

Several studies were conducted to evaluate the effect of water and feed restriction on growth performance

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parameters of fattening rabbits [11, 13-15]. However, there was a lack of research papers dealing with breed effect on the performance of fattening rabbits subjected to different regimes of water restriction. Therefore, the current study was designed to investigate the effect of restricted water intake on growth performance, behavior, carcass and blood parameters on fattening rabbits as well as to estimate breed effect of these parameters.

MATERIALS AND METHODS

This experiment was carried out in a laboratory animal unit of the department of animal husbandry and animal wealth development, faculty of veterinary medicine, Alexandria University, Egypt throughout the period from January to April 2013.

Animals: Total number of sixty growing rabbits of two breeds (30 of Alexandria rabbits and 30 New Zealand White rabbits) at 35 days of age and average weight about 500 g. Each breed divided into three groups; the first group was controlled one (10 Alexandria and 10 New Zealand White rabbits) and had free access to drinking water, a second group (10 Alexandria and 10 New Zealand White rabbits) had a limited access to drinking water 2 h. /day from 9 am until 11 am, while the third group (10 Alexandria and 10 New Zealand White rabbits) had a limited access to water 3 h. /day from 9 am until 12 noon (Fig. 1).

Each group of 10 rabbits within each breed was allocated into two replicates (5 rabbits /cage). Animals were housed in open system doors and provided with galvanized wire cage batteries (55×45×30 cm/cage) and 14-16 h of light/day. Daily temperatures ranged between 16 to 24°C and 60 to 75% relative humidity. Rabbits were fed ad-libtium with commercial pelted diet contained the following nutrients as shown by the factory label (Crude protein 18%, Crude fiber 12%, Fat 3%, Arginine 0.9%, Lysine 0.7%, Methionine and cysteine 0.79%, Ca 0.7%, Ph 0.5% and Metabolized energy 2600 kcal/kg).

Rabbit were fed the ration from feeding trough placed at the side of the cage and daily weighting the amount of feed consumption for each cage as the differences between amount of feed added at 9 am and the amount of remaining feed at the next day at 9 am. Also, drinking water supplied by water trough at the side of the cage. The remaining water of restricted groups was measured at 11am and 12 noon for 2h and 3h/day groups; respectively and calculate the differences between supplied and remaining water to calculate water intake, while water intake of free access groups was measured daily at 9 am as the differences between remaining and supplied water. All treated groups subjected to the water restriction regime from 35 to 63 days of age, then allowed to free access of water from 63 to 70 days of age [11].

Studied Parameters

Growth Performance Parameters: Body weight (BW) was recorded weekly from 35 to 70 days of age, daily weight gain (DWG) and relative growth rate (RGR) also recorded for the same periods. Daily Feed consumption (DFC), daily water consumption (DWC) and feed conversion ratio (FCR) were recoded for all groups.

Carcass traits: three rabbits from each group were randomly taken, fasted for 12 h, weighed individually and slaughtered (to complete bleeding) according to Islamic rules (cut through the neck, reaching through the trachea, esophagus, the jugular veins and carotid arteries, without severing the spinal cord). After complete bleeding, rabbits were weighed and skinned. Dressing percentage, head, liver, heart, spleen, kidneys, pancreas and abdominal fat percentages were estimated.

Blood parameters: at the end of the experiment (At slaughter) three Blood samples were collected under vacuum in heparinized tubes from each experimental group. At collection time, 3-5 ml of blood was drained. Blood samples were kept for assaying of RBCs, Hb, HCT, MCV, MCH, MCHC, WBCs, Lymphocytes, Granulocytes and Platelets.

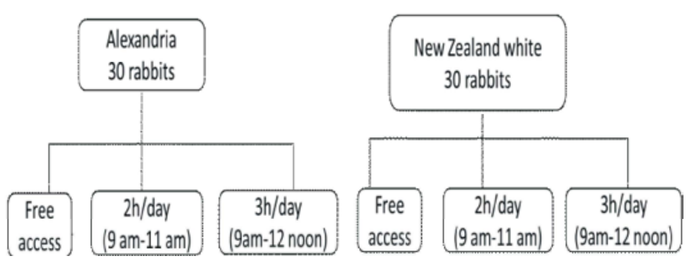

Fig. 1: Experimental design for water restricted two breeds of rabbits

Behavioral Observations: Carried out by the observer from 5 am till 7 pm (day light period), a sample from five rabbits from each group were identified by different color paints for behavioral observation and the behavior patterns recorded were:

- Ingestive behavior: Feeding (min/h): Time spend by the rabbit hopping the feeding trough, drinking (min/h) Time spend by the rabbit drinking from the water trough.
- Ceacotrophy (No/h): The rabbit's touches the anus with the mouth.
- Resting (min/h): Sitting, sternal lying and lateral lying.
- Body care (No/h): Licking, scratching or nibbling the body or the hair. Movement activities (No/h): walking or running.
- Exploratory behavior (No/h): Exploration of cage, trough and other exploration.

Statistical Analysis: Data collected were subjected to analysis of variance (GLM) to assess significant differences between breeds and groups with the aid of SAS [16] according to the following model: $X_{ijk}=\mu + B_i + G_j + E_{ijk}$ Where: X_{ijk} = the X_{th} observation of the breed. μ = overall mean. B_i = effect of breed (i = Alexandria and New Zealand White rabbits). G_j = effect of group (j = free access, 2 h /day and 3 h /day). e_{ijk}= random error.

RESULTS AND DISCUSSION

Growth Performance: Data of growth performance (BW, DWG and RGR) are presented in Table (1) while those of DWC, DFC and FCR are shown in Table (2).

It was clear that initial BW of the two rabbit breeds at 35 days of age were non-significant among control and WR groups, these results also showed that there were non-significant differences between control and WR groups of Alex and NEW rabbits from 35 -70 days of age, however; control groups showed higher non-significant increase in final body weight (70 days of age) than WR groups followed by WR 3 h/day group, while WR 2 h/day group represented the lowest means for BW either for Alex or NEW rabbits. Similar results were recorded by Bergaoui *et al*. [17] who found that feed restriction significantly affected daily weight gain and reduced the growth and final weight of Hyla rabbits.

Table 1: Means ± Standard Errors (Mean ± SE) of some growth parameters of two rabbit breeds subjected to two systems of WR.

	Alex			NZW		
Item	Free access	2 hours	3 hours	Free access	2 hours	3 hours
Body weight						
W35	498.00±38.57	507.63±43.52	540.44±45.75	507.60±35.36	516.30±24.96	516.30±35.33
35-42	740.00±71.24	752.63±54.89	774.00±65.14	748.40±39.99	709.40±34.04	713.70±50.43
42-49	938.44±74.64	944.50±53.40	975.44±71.48	1047.00±45.37	950.80±49.28	986.22±62.13
49-56	1117.44±87.23	1170.75±67.42	1176.33±85.41	1272.89±57.84	1124.56±56.99	1161.78±70.76
56-63	1369.67±96.13	1361.88±94.99	1406.11±100.03	1541.89±60.90	1400.00±66.50	1441.67±60.02
63-70	1539.56±91.10	1472.50±98.39	1500.22±91.53	1711.00±56.68	1523.89±54.46	1561.67±66.29
Daily weight gain						
35-42	29.60±3.81	34.99±3.48	33.37±3.89	34.40±1.90	27.59±3.65	28.20±4.18
42-49	28.35±2.43[b]	27.41±1.97[b]	28.78±3.12[ab]	40.32±3.47[a]	34.49±5.00[ab]	34.87±5.06[ab]
49-56	25.57±2.62	32.32±3.10	28.69±3.91	32.27±2.54	22.75±2.40	25.08±3.17
56-63	36.03±2.72[ab]	27.31±4.70[b]	32.82±3.95[ab]	28.43±1.14[a]	39.50±3.33[a]	39.99±2.26[a]
Overall restricted	29.35±1.73[b]	30.51±2.05[ab]	30.92±2.80[ab]	36.50±1.45[a]	31.38±2.02[ab]	32.45±1.41[ab]
63-70	24.27±1.41[a]	15.80±2.20[b]	13.45±2.52[b]	24.16±2.37[a]	17.70±2.44[ab]	17.14±2.06[ab]
Overall 35-70	28.34±1.21[b]	27.57±1.86[b]	27.42±2.10[b]	34.03±1.01[a]	28.64±1.30[b]	29.38±1.26[b]
RGR						
35-42	33.77±2.07	39.34±3.40	35.72±3.74	39.10±2.59	29.84±4.87	31.87±4.14
42-49	24.76±2.66	23.29±2.19	23.69±2.87	31.42±2.60	28.86±4.07	27.80±3.82
49-56	17.53±1.46[ab]	21.30±1.71[a]	18.80±2.36[ab]	19.42±1.17[ab]	15.24±1.51[b]	16.50±2.30[ab]
56-63	20.79±1.90[a]	14.69±1.62[b]	17.86±2.07[ab]	19.30±0.77[ab]	21.94±1.73[a]	22.28±2.21[a]
Overall restricted	91.32±1.78	91.83±2.89	89.09±6.14	99.82±3.52	91.24±3.89	92.42±3.11
63-70	12.24±1.27[a]	7.90±1.10[ab]	6.97±2.24[b]	10.55±1.05[ab]	8.87±1.44[ab]	7.98±0.91[ab]
Overall 35-70	100.98±2.25[ab]	97.83±2.39[ab]	94.50±6.00[b]	107.50±3.37[a]	98.14±3.43[ab]	98.59±2.94[ab]

Means bearing different letters within the same row are significantly different at ($P<0.05$).

Table 2: Means ± Standard errors (Mean ± SE) of water and feed consumption as well as feed conversion ratio of two rabbit breeds subjected to two systems of WR

Item	Alex			NZW		
	Free access	2 hours	3 hours	Free access	2 hours	3 hours
Daily water consumption (DWC)						
35-42	189.93±12.37[a]	80.79±5.30[c]	98.67±4.81[c]	143.49±11.07[b]	81.68±8.00[c]	88.74±6.15[c]
42-49	222.74±6.06[a]	91.96±3.59[c]	100.38±5.24[c]	176.53±6.82[b]	91.09±6.76[c]	92.57±4.75[c]
49-56	237.93±8.32[a]	125.73±2.18[b]	135.77±8.44[b]	234.86±9.39[a]	125.89±8.72[b]	137.93±5.48[b]
56-63	283.86±12.34[a]	166.83±4.50[b]	188.04±13.83[b]	279.07±12.53[a]	137.13±7.09[c]	195.66±7.36[b]
Overall restricted	233.61±5.27[a]	116.33±2.53[de]	130.71±5.54[c]	208.49±5.69[b]	108.95±4.27[e]	128.73±4.23[cd]
63-70	253.39±11.56[b]	592.14±52.87[a]	442.79±33.40[b]	389.71±22.23[b]	357.54±39.20[b]	442.39±30.26[b]
Overall 35-70	257.57±21.40[a]	210.74±43.09[b]	193.13±36.81[b]	244.73±16.57[a]	158.66±35.99[c]	191.46±30.81[b]
Daily feed consumption (DFC)						
35-42	66.85±4.36[a]	51.19±2.69[c]	58.40±2.72[abc]	61.41±1.90[ab]	51.35±4.22[c]	54.36±2.18[bc]
42-49	70.25±3.39[ab]	67.10±2.32[ab]	57.49±2.46[c]	76.04± 3.62[a]	62.89±3.04[bc]	64.83±3.40[bc]
49-56	93.98±5.50[ab]	83.40±1.63[bc]	75.10±4.35[c]	96.41±3.66[a]	74.07±5.40[c]	75.35±2.65[c]
56-63	107.54±3.55[a]	90.64±5.06[b]	94.76±3.02[b]	117.72±4.25[a]	94.77±3.63[b]	85.58±3.01[b]
Overall restricted	84.65±2.15[a]	73.08±1.36[b]	71.44±1.75[b]	87.90±1.43[a]	70.77±3.39[b]	70.03±1.43[b]
63-70	121.03±3.96	113.69±5.15	127.07±5.47	126.26±2.88	119.53±7.51	126.65±4.90
Overall 35-70	91.28±1.80[a]	81.20±1.63[b]	82.56±1.90[b]	95.57±1.10[a]	80.52±4.06[b]	81.35±1.54[b]
Feed conversion ratio (FCR)						
35-42	2.26	1.46	1.75	1.79	1.86	1.93
42-49	2.48	2.45	2.00	1.89	1.82	1.86
49-56	3.68	2.58	2.62	2.99	3.26	3.00
56-63	2.98	3.32	2.89	4.14	2.40	2.14
Overall restricted	2.88	2.40	2.31	2.41	2.26	2.16
63-70	4.99	7.20	9.45	5.23	6.75	7.39
Overall 35-70	3.22	2.95	3.01	2.81	2.81	2.77

Means bearing different letters within the same row are significantly different at (P<0.05).

Regarding DWG, control group of NEW rabbit recorded higher non-significant increase in DWG than other groups at overall restricted period from 35-63 days of age (36.50 g/day) while, it recorded the highest significant DWG among all groups at overall experimental period from 35-70 days of age (34.03 g/day). Moreover, overall RGR revealed higher non-significant increase for control group of Alex and NEW rabbits than WR groups (100.98 and 107.50 %, respectively). Ben Rayana *et al.* [10] reported that daily weight gain decreased (P<0.01) with the degree of water restriction regimes (36.9, 32.8 and 29.9 g/d respectively for control, 2 h/day and 4 h/ day).

Concerning DWC, treated groups of Alex and NEW rabbits consumed water significantly lower than control ones of both breeds at overall restricted period (35-63 days of age) and overall experimental period (35-70 days of age). Free water intake in rabbits decreased linearly and significantly (P<0.05) as the duration of water deprivation increased [18]. Similarly, DFC followed the same trend of DWC where, WR groups of both Alex and NEW rabbits consumed feed significantly lower than control groups of the studied breeds, these results indicated that WR used as an indirect factor to reduce FC. Several reports noticed a direct correlation between WR and FC; Boisot *et al.* [19] reported 18.1% feed intake reduction after 28 days period of restricted access to drinking water of 2h/ day. Moreover, Verdelhand *et al.* [14] recorded decreased feed intake to 78 and 83% of the ad libitum level in response to 1h 30 and 2h 30 access drinking water per day from 32 - 62 d of age. Also, Ben Rayana *et al*. [10] obtained feed intake reduction of 25 and 20% due to WR of 2 or 4 h/ day continuously from weaning (28 days) to slaughter (77 days). Furthermore, Elmaghraby [11] and Bovera *et al.* [20] reported feed intake reduction in water restricted post weaning rabbits.

It was clear that, WR groups 2 h/day and 3 h/day of both Alex and NEW rabbits showed improved FCR at overall restricted period (35-63 days) and overall experimental period (35-70 days of age) in comparison with those of control ones of either Alex or NEW rabbit breeds. The improvement of FCR explained as WR groups consumed feed significantly lower than free access groups and recorded non-significant differences in body weights in comparison with those of free access ones of

Table 3: Means ± Standard errors (Mean ± SE) of carcass and blood parameters of two rabbit breeds subjected to two systems of WR

	Alex			NZW		
Item	Free access	2 hours	3 hours	Free access	2 hours	3 hours
Carcass parameters (%)						
Dressing	46.30±0.28[ab]	47.10±1.09[ab]	44.31±0.61[b]	47.60±1.60[a]	44.26±0.60[b]	45.55±1.02[ab]
Head	6.86±0.32	6.74±0.64	7.49±0.26	6.73±0.23	7.06±0.10	6.66±0.15
Liver	2.97±0.21[ab]	3.17±0.13[ab]	3.05±0.15[ab]	2.43±0.14[b]	3.26±0.22[ab]	3.44±0.51[a]
Heart	0.39±0.04	0.33±0.01	0.35±0.05	0.36±0.02	0.34±0.01	0.37±0.03
Spleen	0.08±0.01[ab]	0.14±0.03[a]	0.09±0.03[ab]	0.08±0.01[ab]	0.06±0.01[b]	0.07±0.02[b]
Kidneys	0.80±0.03	0.93±0.17	1.02±0.25	0.72±0.02	0.71±0.02	0.78±0.07
Pancreas	0.15±0.01	0.22±0.07	0.17±0.03	0.18±0.04	0.11±0.01	0.17±0.01
Abdominal fat	0.56±0.10	0.33±0.08	0.29±0.03	0.50±0.13	0.28±0.09	0.36±0.08
Blood parameters						
RBCs	6.10±0.03[a]	5.95±0.[ab]	4.95±0.02[c]	5.96±0.03[b]	4.98±0.02[c]	5.95±0.02[b]
Hb	11.77±0.15[b]	12.33±0.03[a]	10.47±0.15[c]	12.33±0.12[a]	10.23±0.09[c]	12.10±0.12[ab]
HCT	28.30±0.57[a]	27.70±0.06[ab]	22.20±0.21[b]	28.10±0.12[a]	22.10±0.23[b]	27.00±0.46[b]
MCV	47.00±0.91[a]	46.93±0.38[a]	46.03±0.12[ab]	46.33±0.72[ab]	45.07±0.09[b]	46.17±0.13[ab]
MCH	19.40±0.26[c]	20.83±0.35[b]	20.67±0.26[b]	21.70±0.35[a]	20.93±0.09[ab]	20.47±0.20[b]
MCHC	41.37±0.98[c]	44.57±0.19[b]	45.20±0.25[ab]	44.17±0.35[b]	46.33±0.19[a]	45.67±0.52[ab]
WBCs	5.70±0.15[e]	13.57±0.19[b]	14.37±0.18[a]	7.40±0.15[c]	5.80±0.12[e]	6.30±0.12 [d]
Lymphocytes	62.57±0.58[a]	33.40±0.95[d]	27.67±0.23[e]	52.60±0.32[b]	52.87±0.67[b]	43.97±0.22[c]
Granulocytes	29.33±0.41[d]	57.37±0.75[b]	67.07±0.09[a]	38.27±0.34[c]	36.80±0.55[c]	37.03±0.50[c]
Platelets	439.00±9.29[a]	129.00±1.15[b]	29.67±0.67[d]	99.00±1.15[c]	39.33±0.88[d]	31.33±0.88[d]

Means bearing different letters within the same row are significantly different at ($P<0.05$).

both breeds. Our results are in agreement with the findings of Bovera *et al*. [21] who reported better FCR in feed restricted rabbits over the whole fattening period. Furthermore, Bergaoui *et al.* [17] reported improved FCR by 5 and 8% respectively for R85 % and R70% of ad-libitum feed intake rabbits. In contrast, Boisot *et al.* [19] did not observe compensatory growth in rabbits subjected to restricted access to DW of 2 and 3 h between 35 and 63 days of age. Our results also disagreed with those obtained by Gualterio *et al*. [22] who found that FCR was lower in WR groups in comparison with those of control one. Furthermore, Bovera *et al.* [20] reported that FCR was lower for the WR group rabbits.

Carcass Characteristics: Results in Table (3) showed that different treatments had no significant carryover effect on most of carcass parameters (head, heart, kidneys and pancreas percentages). While, the abdominal fat percentage decreased in WR groups in comparison to control groups.

The NZW rabbit had a higher non-significant dressing percentage with free access than a NZW rabbit with WR 2 h/ day and Alex rabbit with WR 3 h/ day, respectively. In addition, higher liver percentage was observed with a NZW rabbit with WR 3 h/ day compared with other groups. A higher spleen percentage was recorded for WR 2 h/ day Alex rabbits in comparison with other groups. Similarly, other reports indicated little impact of a variety of restriction protocols on carcass traits [11, 13, 19, 23-25]. Moreover, with quantitative and time FR, dressing percentage decreased within the range of -1.2 to -0.8% than control group [26-28].

Blood Parameters: The data presented in Table (3), showed that free access of water Alex rabbits group had higher means for RBCs numbers, HCT, MCV, lymphocytes and blood platelets than the other groups. While, WR 2 h/ day Alex rabbits and free access of water NZW rabbit had significantly higher Hb than the other groups. Moreover, free access water groups NZW rabbits had significantly higher MCH compared to the other groups. The WR 2 h/ day NZW rabbits had non-significantly higher MCHC than the other groups, while the highest significant values for WBCs and granulocytes was recorded for Alex rabbits WR 3 h/ day group. El-Moty and El-Moty [29] concluded that hematocrit was significantly decreased by feed restriction in rabbits. Moreover, Ebeid *et al.* [30] reported that feed restriction significantly reduced the RBCs number and Hb concentration, meanwhile MCV was increased, but had no significant effect on WBCs numbers and HCT value.

Table 4: Means ± Standard Errors (Mean ± SE) of some behavioral performance of two rabbit breeds subjected to two systems of WR.

	Alex			NZW		
Item	Free access	2 hours	3 hours	Free access	2 hours	3 hours
Ingestive behavior						
Feeding (min/h)	9.83±1.16	9.24±1.06	11.17±1.12	11.85±1.49	12.00±1.59	11.17±1.03
Ceacotrophy (No/h)	0.01±0.02^{b}	4.21±1.30^{a}	0.00±0.00^{b}	0.00±0.00^{b}	0.02±0.02^{b}	0.02±0.02^{b}
Drinking (min/h)	2.40±0.46^{a}	0.97±0.38^{b}	0.75±0.29^{b}	2.42±0.45^{a}	1.25±0.53^{ab}	1.58±0.44^{ab}
Resting behavior (min/h)						
Sitting	11.77±1.39^{b}	19.10±1.72^{a}	15.17±1.59^{ab}	15.67±1.59^{ab}	16.08±1.68^{ab}	15.33±1.74^{ab}
Sternal laying	31.58±2. 09^{a}	22.64±2.00^{b}	26.33±1.94^{ab}	26.08±2.09^{ab}	26.75±1.89^{ab}	23.25±1.95^{b}
Lateral laying	3.33±0.66^{b}	3.61±0.88^{b}	6.58±1.57^{ab}	3.83±0.95^{b}	4.25±1.26^{b}	8.83±1.61^{a}
Movement activities (No/h)						
Walking	0.40±0.11^{abc}	0.33±0.09^{bc}	0.32±0.08^{bc}	0.60±0.11^{ab}	0.27±0.07^{c}	0.68±0.12^{a}
Running	0.00±0.00^{b}	0.32±0.14^{a}	0.08±0.05^{ab}	0.17±0.10^{ab}	0.02±0.02^{b}	0.20±0.07^{ab}
Body care (No/h)						
Licking	0.90±0.15^{b}	1.00±0.13^{b}	0.95±0.13^{b}	1.57±0.23^{a}	1.12±0.21^{ab}	0.68±0.12^{b}
Scratching	0.37±0.10^{a}	0.26±0.06^{ab}	0.18±0.06^{ab}	0.37±0.08^{a}	0.08±0.04^{b}	0.07±0.03^{b}
Exploratory behavior (No/h)						
Exploration of cage	0.20±0.07	0.26±0.06	0.23±0.06	0.15±0.05	0.28±0.07	0.17±0.07
Exploration of others	0.08±0.04^{ab}	0.10±0.04^{a}	0.03±0.02^{ab}	0.00±0.00^{b}	0.08±0.04^{ab}	0.05±0.03^{ab}
Exploration of trough	0.02±0.00	0.01±0.00	0.00±0.00	0.00±0.00	0.02±0.00	0.02±0.00

Means bearing different letters within the same row are significantly different at ($P<0.05$).

But in poultry hematological values were significantly influenced by severity of water restrictions, However WBCs increased in WR group [31]. Moreover, Tumova *et al*. [12] reported an increased number of lymphocytes in feed restricted rabbits

Behavioral Parameters: Data of behavioral performance parameters are presented in Table (4). Despite, the WR had no significant effect on feeding time among groups of both Alex and NZW rabbits, free access and WR groups of NZW rabbits had a higher feeding time than Alex rabbits. However, ceacotrophy frequency was higher in WR (2 h and 3 h) than free access groups. In fact, the domestic rabbit is no longer without eating, since it has more than 20 meals of dry feed a day and it also has meals of caecotrophes (Early morning). Moreover, Hirakawa [32] pointed out that leporids (Including rabbits) also consumed a part of their own hard faeces that are masticated contrary to soft faeces that are swallowed. Rabbits of WR groups recorded the higher ceacotrophy frequencies than free access ones of both breeds as they drink small amount of water and this induced low feed consumption so increased eating their soft faeces. Moreover, drinking time increased significantly in free access groups than WR groups (2 h and 3 h) either in Alex or NZW breeds.

The effect of WR on resting behavior of growing rabbit revealed significant differences between the WR and free access water intake groups in sitting, sternal lying and lateral lying time. Alex rabbits of WR 2h/day group had the highest sitting time, however the highest sternal lying time was observed for free access Alex rabbits. On the other hand, WR 3h /day NZW rabbits recorded highest lateral lying.

Results of movement activities revealed that the highest walking frequencies were observed for WR 3 h/ day NZW rabbits. However, the highest running frequencies were recorded for the WR 2h / day Alex rabbits. Verdelhan *et al*. [14] found that limited access to water, the rabbit moving each day for about 10 minutes around the drinker and they rushed to drink after drinking the rabbits ate their diets, then they calmed down in the cage.

Regarding the effect of WR on the body care behavior of growing rabbits, the highest licking frequency was recorded for free access water intake NZW rabbits. While the highest scratching frequency recorded for both free access water intake Alex and NZW rabbits. The investigatory behavior of growing rabbits significantly affected by WR, the higher frequencies were observed for restricted groups in both breeds, this was for needs for water.

Table 5: Means ± Standard errors (Mean ± SE) for overall growth performance parameters of two rabbit breeds subjected to two systems of WR

Parameter	Alex	NZW	Significance
Body weight			
W0	515.08±24.50	513.40±17.07	NS
35-42	755.65±36.05	723.83±22.45	NS
42-49	953.16±37.94	993.11±29.71	NS
49-56	1154.23±45.51	1186.41±36.64	NS
56-63	1379.88±54.08	1461.19±36.60	NS
63-70	1505.31±52.07	1598.85±36.54	NS
Daily weight gain			
35-42	32.69±2.16	30.06±1.88	NS
42-49	28.21±1.44	36.49±2.55	*
49-56	28.73±1.89	26.70±1.71	NS
56-63	32.24±2.23	39.26±1.35	*
Overall restricted	30.29±1.29	33.44±1.01	NS
63-70	17.92±1.78	19.67±1.42	NS
Overall 35-70	27.76±1.00	30.69±0.81	*
RGR			
35-42	36.26±1.85	33.60±2.23	NS
42-49	23.94±1.46	29.34±1.97	*
49-56	19.13±1.09	17.05±1.02	NS
56-63	17.90±1.16	21.17±0.97	*
Overall restricted	90.68±2.39	94.49±2.09	NS
63-70	9.08±1.03	9.13±0.67	NS
Overall 35-70	97.64±2.50	101.41±1.99	NS
Water consumption			
35-42	123.13±8.79	104.64±6.51	*
42-49	138.36±9.76	120.06±7.14	*
49-56	166.47±8.83	166.23±8.86	NS
56-63	212.91±10.08	203.95±10.51	NS
Overall restricted	160.22±8.57	148.72±7.24	*
63-70	462.77±25.77	396.55±18.47	*
Overall 35-70	220.48±6.76	198.29±7.05	*
Feed consumption			
35-42	58.81±2.13	55.71±1.79	NS
42-49	64.95±1.77	67.92±2.10	NS
49-56	84.16±2.63	81.94±2.79	NS
56-63	97.65±2.50	99.36±2.95	NS
Overall restricted	76.39±1.36	76.23±1.82	NS
63-70	120.59±2.89	124.14±3.10	NS
Overall 35-70	85.02±1.22	85.81±1.81	NS
Feed conversion ratio			
35-42	1.82	1.86	
42-49	2.31	1.86	
49-56	2.96	3.08	
56-63	3.06	2.89	
Overall restricted	2.53	2.28	
63-70	7.21	6.46	
Overall 35-70	3.06	2.80	

NS=non-significance differences (P=0.05) *=significant at (P<0.05)

Table 6: Means ± Standard errors (Mean ± SE) for breed effect on carcass, blood and behavioral parameters of two rabbit breeds subjected to two systems of WR

Parameter	Alex	NZW	Significance
Carcass parameters			
Dressing %	45.90±0.56	45.80±0.75	NS
Head %	7.03±0.25	6.82±0.10	NS
Liver %	3.06±0.09	3.04±0.23	NS
Heart %	0.36±0.02	0.36±0.01	NS
Spleen %	0.10±0.01	0.07±0.01	*
Kidneys %	0.92±0.09	0.74±0.02	NS
Pancreas %	0.18±0.02	0.15±0.02	NS
Abdominal fat %	0.39±0.06	0.38±0.06	NS
Blood parameters			
RBCs	5.67±0.18	5.63±0.16	NS
Hb	11.52±0.28	11.56±0.34	NS
HCT	26.07±0.99	25.73±0.93	NS
MCV	46.66±0.33	45.86±0.29	NS
MCH	20.30±0.27	21.03±0.22	*
MCHC	43.71±0.66	45.39±0.37	*
WBCs	11.21±1.39	6.43±0.27	*
Lymphocytes	41.21±5.41	49.81±1.48	*
Granulocytes	51.26±5.66	37.37±0.33	*
Platelets	199.22±61.69	56.56±10.69	*
Behavioral parameters			
Ingestive behaviour			
Feeding	10.03±0.64	11.6±0.80	NS
Ceacotrophy	1.59±0.51	0.01±0.00	*
Drinking	1.35±0.23	1.75±0.27	NS
Resting behavior			
Sitting	15.58±0.94	15.69±0.96	NS
Sternal laying	26.59±1.19	25.36±1.14	NS
Lateral laying	4.45±0.63	5.64±0.76	NS
Movement activities			
Walking	0.35±0.06	0.52±0.06	*
Running	0.15±0.06	0.13±0.04	NS
Body care behavior			
Licking	0.95±0.08	1.12±0.11	NS
Scratching	0.27±0.04	0.17±0.03	NS
Exploration behavior			
Explor. of cage	0.23±0.04	0.20±0.04	NS
Explor. of other	0.07±0.02	0.04±0.02	NS
Explor. of trough	0.01±0.01	0.01±0.01	NS

NS=non-significance differences (P=0.05) *= significant at (P<0.05)

Effect of Breed: Data in Table (5) showed that breed (Alex and NZW) had no significant effect on BW, RGR and DFC at 35–70 days of age. However, the NZW rabbit had significantly higher DWG at 35-70 days of age and recorded the best FCR at both overall restricted period (35-63 d) and overall experimental period (35-70 d) than Alex rabbits, while Alex rabbit consumed water significantly higher than the NZW rabbits. The NZW had significantly higher body gain than Californian, Palomino and White Satin rabbits [33]. On the other hand, no significant differences between NZW and Soviet Chinchilla breeds of rabbits [34].

Data of breed effect on carcass, blood and behavioral parameters are presented in Table (6). Breed of rabbit (Alex and NZW) had no significant effect on most of carcass traits (dressing, head, liver, heart, kidneys, pancreas and abdominal fat percentages), while Alex rabbit had significantly higher spleen percentage than the NZW rabbit. Alex and NZW rabbits had no significant effect on RBCs, Hb, HCT and MCV, while NZW rabbit had significantly higher MCH, MCHC and lymphocytes and had significantly lower WBCs, granulocytes and platelets than Alex rabbit.

Regarding breed effect on behavioral parameters, there were no significant effects on resting, body care, exploration, running and ingestive behavior. On the other hand, ceacotrophy was significantly higher for Alex rabbit, while NZW rabbit had significantly higher walking frequencies than Alex rabbit.

CONCLUSION

In conclusion, the results of this study confirmed that WR can be used as a successful alternative factor for feed restriction, which easy to be applied to improve the growth performance of fattening rabbits, beside, saving additional costs for rabbit production programs

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