Archives of Agriculture Sciences Journal
Print ISSN: 2535-1680
Online ISSN: 2535-1699

ARCHIVES OF AGRICULTURE SCIENCES JOURNAL
Volume 8, Issue 2, 2025, Pages 54–64
Available online at https://aasj.journals.ekb.eg
DOI: https://dx.doi.org/10.21608/aasj.2025.455376

Impact of season and production system on productivity indices of rabbits under climatic conditions in Egypt

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Abstract

The aim of the present study is to investigate the effect of rabbit production systems and season of the year on rabbit's productivity. A longitudinal survey was conducted through face-to-face interviews with a structured questionnaire during the two main seasons of the year: almost hot season (from April to September, with an average THI 25.7 ± 1.2) and almost cold season (from October to March, with an average THI 15.8 ±1.9). The highest significant number of litter size at birth, number of fattening kits and total number of weaning kits per doe were detected under the commercial and semi-commercial rabbit production systems as compared to the family system. The commercial system attained the highest significant weaning weight (601.09 g) compared to the semi-commercial (520.83g) and family systems (363.19g). All rabbit productive performance indices (litter size at birth, litter number in season, number of fattening kits at the end of fattening period, weight at weaning, marketing weight, number of weaning kits /doe/years, fertility percentage) were significantly higher under the almost cold weather period compared to the almost hot period.

Keywords: Climatic conditions, rabbit production systems, season.

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1. Introduction

Animal production development is considered a main concern by the Egyptian government to reduce poverty. In addition, increasing animal production could achieve food security and bridge the huge gap between animal protein supply and intake. Rabbit production is one of the main sources of income for unemployed youth and is considered a cheap alternative source of animal protein. Rabbit production, which is a part of livestock production, has a special privilege as a result of its high growth rate, high conversion efficiency, short gestation period, high productivity rate, quiet nature, and ease of backyard raising. According to Khan *et al.* (2012), rabbit production is considered a principal source of income for many villagers to meet the family needs and obligations, improve living standard and nutritional levels of poor families. Rabbits are simple to raise and less competitive for human food sources than other livestock animals (Haque *et al.*, 2016). Their meat is of high quality, palatable, and unrestricted by social customs. Rabbits are quite effective at turning fodder into meat (Chipo *et al.*, 2019). Susceptibility of rabbits to heat stress in Egypt (subtropical climate) is considered a great problem, especially in commercial production. Period of the year (heat stress) adversely affects animal welfare, performance, and yield (Azoz and El-Kholy, 2006; El-aaser, 2007; Marai *et al.*, 2004; Sharaf *et al.*, 2019). Rabbits experience heat stress more than any other agricultural animal and have very poor thermoregulation because they have thick fur covering their bodies and lack of sweat glands (Oladimeji *et al.*, 2022). Heat stress describes an animal's reactions to a warmer environment than its comfort zone (Kang *et al.*, 2020; Saracila *et al.*, 2020). The thermo-neutral zone of rabbits is between 18 and 21°C. Thus, a relative increase in the ambient temperature, higher than 24-25°C, reduces feed intake. Rabbits are heat-stressed when exposed to 30°C. It is a significant issue in the production of rabbits, particularly in the tropics and during summer heat waves in temperate countries (Farghly *et al.*, 2020). Climatic change makes the issue much more challenging (Lamarca *et al.*, 2018). Litter traits (litter size, litter weight, and pre-weaning litter mortality) were found to be affected by environmental aspects. Mortality rate could be viewed as a key component in assessing both the environmental and productive aspects of rabbit farms (Gaillac and Marbach, 2021). In Egypt, rabbit production systems can be classified into three main types. The family system involves keeping a small number of breeding does, usually between 1 and 7, with rabbits not serving as a primary source of income. The semi-commercial system is characterized by a larger number of breeding does, typically between 8 and 45, where rabbits represent an important source of income. The commercial system includes the largest herds, generally between 50 and 400 breeding does, and relies heavily on rabbits as a main source of income (Gebril *et al.*, 2023). According to the knowledge of the authors, there are very limited studies about rabbit production systems in Egypt under climatic conditions. Therefore, the aim of the present work is to study the effect of rabbit production systems, the season of the year, and their interaction on rabbit productivity.

2. Materials and methods

Two Egyptian governorates were selected, Al-Minya and Al-Qalyubiya, where Al-Minya represents the Middle Egypt region, and Al-Qalyubiya represents the region of the Nile Delta. The geographical coordinates of Al-Minya are 28.11° N and 30.11°E. Al-Minya governorate is dry throughout the year. The average precipitation is 14.59 mm/year, the human population is around 5.8 million, which is about 5.1% of the whole population of Egypt, and the total area is 32,279 km^2, representing 3.2% of the total area of Egypt. The human development index was 0.657 in 2017. Al-Qalyubiya coordinates are 30°18'0" N and 31°18'0" E, the total population reached 5,703,000, it has an average of precipitation rate of 39 mm/year, the total area is 1,001 km^2, and the human development index was 0.698 in 2017. The climatic conditions in the study areas are of the subtropical type, June is the warmest month with an average of 37°C, while the coldest one is January with an average of 20°C. The month with the highest relative humidity is December (67%), the month with the lowest relative humidity is May (37%).

2.1 Data collection

A longitudinal survey was conducted during the two main seasons of the year: almost hot (period one) from April to September 2021 and almost cold (period two) from October 2021 to March 2022. The Egyptian climate is characterized by warm days and cold nights. Goma and Phillips (2021) indicated that there are two main seasons in Egypt: a mild winter (November to April) and a hot summer from May to October. The current study had a total number of 200 householders who are engaging in rabbit) All rabbit breeds (raising and production. The data was collected through face to face interviews with a structured questionnaire from farmers and direct observation. The questionnaires had both open and closed-ended questions which were clear and easy to understand. The questionnaires were pilot tested with 10 rabbit keepers in each governorate. The thermo-neutral zone of rabbit is between 18 and 21 ºC, in which rabbit makes no effort to raise or reduce its temperature (Zeferino *et al.*, 2011). The temperature humidity index (THI) was calculated (Table 1) using the formula reported by Marai *et al.* (2001) as an indicator to the comfort zone of rabbits under the production system:

$$THI = T - (0.31 - 0.31 \times RH) \times (T - 14.4)$$

Where: t = temperature (ºC) and RH = relative humidity percentage.

2.2. Data analysis

General Linear Model (GLM) of SAS program (SAS, 2010) was used to analyze the variation of continuous data (two-way factorial arrangement, 3×2), F-test was applied to test differences between relevant parameters. Statistically significant differences ($P \leq 0.05$) were indicated by different superscripts. The following linear model was used as follows:

$$Y_{ijk} = \mu + S_i + P_j + (SP)_{ij} + e_{ijk}$$

Where: Yijk is the observed value, μ is the general mean, S_i is the effect of production system, i = 1, 2, 3 (1= family, 2= semi-commercial and 3= commercial), P_j is the effect of season of the year, j =1, 2 (1= almost cold, 2= almost hot), $(SP)_{ij}$ is the interaction between production system and season of the year, e_{ijk} = is the random error.

Table (1): Air temperature, Relative humidity and temperature-humidity index throughout the experimental period in Al –Qalyubiya and Al-Minya.

Season of the year	Months	Average air temperature		Relative humidity		Temperature-humidity index	
		Al -Qalyubiya	Al-Minya	Al-Qalyubiya	Al-Minya	Al-Qalyubiya	Al-Minya
Almost hot (Period one P1)	April-2021	20.50	22.29	51.84	28.81	19.586	20.548
	May-2021	27.56	29.17	39.95	22.69	25.113	25.628
	June-2021	28.57	29.80	44.42	28.23	26.128	26.376
	July-2021	31.12	31.66	45.48	28.34	28.290	27.824
	August-2021	31.43	31.59	47.71	28.90	28.671	27.798
	September-2021	28.52	28.29	52.68	39.30	26.451	25.679
	Average	27.95	28.8	47.013	29.378	25.707	25.642
	Maximum	31.43	31.66	52.68	39.3	28.671	27.824
	Minimum	20.5	22.29	39.95	22.69	19.586	20.548
	SE	1.6178	1.411	1.95670	2.2069	1.3417	1.0938
Almost cold (Period two, P2)	October-2021	24.69	24.10	56.81	44.06	23.30976	22.4206
	November-2021	21.43	20.16	64.11	49.65	20.64792	19.2580
	December-2021	14.59	12.96	66.82	57.66	14.56785	13.1529
	January-2022	11.12	9.50	68.89	61.92	11.43283	10.0784
	February-2022	12.87	12.28	68.44	55.41	13.01776	12.5687
	March-2022	13.92	14.88	61.45	43.15	13.97964	14.7932
	Average	16.4366	15.65	64.42	51.975	16.15929	15.3786
	Maximum	24.69	24.1	68.89	61.92	23.30976	22.4206
	Minimum	11.12	9.5	56.81	43.15	11.43283	10.0784
	SE	2.18923	2.226	1.90377	3.1035	1.921538	1.87905

3. Results and discussion

3.1 Impact of production system on rabbit's productivity

The performance of rabbits under the different rabbit production systems (family, semi-commercial, and commercial are shown in Table (2). Regarding the litter size at birth, the commercial and the semi-commercial rabbit production systems recorded the highest significant number of litter size at birth as compared to the family system being 7.29 and 7.43 versus 6.23 respectively. Cherwon *et al.* (2020) found that the average litter size at birth was 6. The same trend was observed regarding the number of fattening kits at the end of fattening period per doe being 26.64, 22.92 and 16.55 for the commercial, semi-commercial, and family rabbit production systems respectively. The total number of weaning kits/doe/years was 17.91, 24.97, and 28.27 for the family, semi-commercial and commercial rabbit production systems, respectively. The differences among the three production systems were significant (P≤0.01). The family production system recorded the lowest marketing weight and longest fattening period (1682.91 g and 75.99 day) as compared to the semi-commercial (1864.88 g and 56.79 day) and commercial systems (1821.74 and 42.76 day) as shown in Table (2). Regarding the average weight at weaning, the results showed that the rabbits under the commercial system attained the highest significant (P≤0.01) weight (601.09 g) comparable to the semi-commercial (520.83 g) and family systems (363.19 g). The best fertility percentage was detected under the commercial system and semi-commercial being 78.41% and 72.80% comparable to that under the family system being 64.86% (Table 2).

Table (2): Performance of rabbits (LSM ± SE) under the different production systems.

Items	Family system	Semi-commercial system	Commercial system
Litter size at birth	6.23 ±.07 ^{b}	7.29± .12 ^{a}	7.43±.17 ^{a}
Litter number	7.00 ±.1 ^{c}	7.9 ± .16 ^{b}	8.6 ±.29 ^{a}
Still-born mortality %	6.73± .34 ^{b}	8.81± .56 ^{a}	6.70±.76 ^{b}
Mortality percentage of kits	15.52± .84 ^{a}	7.96±1.39 ^{b}	6.39±1.88 ^{b}
Number of fattening kits at the end of fattening period / doe	16.55±.46 ^{c}	22.92±.77 ^{b}	26.64±1.04 ^{a}
Age at weaning (days)	30.75±.25 ^{ab}	30.20±.39 ^{b}	31.51±.53 ^{a}
Weight at weaning (g)	363.19±14.85 ^{c}	520.83±16.04 ^{b}	601.09±21.67^{a}
Mortality % of fattening kits (at selling age)	7.8±.62 ^{ab}	9.9±1.02 ^{a}	6.18±1.38 ^{b}
Marketing weight (g)	1682.91±25.40 ^{b}	1864.88±37.49^{a}	1821.74±50.66 ^{a}
Fattening period (days)	75.99±1.56 ^{c}	56.79±2.33 ^{b}	42.76±3.15 ^{a}
Marketing age (day)	105.03±1.79 ^{c}	86.99±2.68 ^{b}	74.28±3.62 ^{a}
Doe mortality %	4.39±1.18 ^{b}	7.58±1.96 ^{ab}	10.94±2.65 ^{a}
Number of weaning kits / doe/years	17.91±.45 ^{c}	24.97±.74 ^{b}	28.27±.10 ^{a}
Gestation period (days)	32.49±.20 ^{a}	30.56±.30 ^{b}	31.07±.41 ^{b}
Fertility percentage	64.86±1.73 ^{b}	72.80±1.90 ^{a}	78.41±2.60 ^{a}

^{a,b} Means within the same row having different superscripts differ significantly (p≤0.05).

3.2 Impact of season of the year on rabbit's productivity

Temperature is one of the most main climatic factors which might affect rabbit performance. The higher the ambient temperature the greater was the disturbance of the rabbit's performance and the mortality rate amongst the offspring also semen characteristics in bucks are affected. Elevated temperature and humidity as presented in THI has a negative effect on the production and reproduction performance of rabbits. The optimal temperature humidity index for rabbits is less than 27.8 (Sakr *et al.*, 2019). Rabbits rely on respiratory evaporation (breathing rate) for the regulation of body temperature and this allows only a limited ability for adaptation to hot weather. Rabbit's furry hinders heat dissipation by radiation and convection, but the ears helped this process. Table (2) showed the performance of rabbits under the two main seasons of the year (almost cold weather period and almost hot weather period). The average number of litter size at birth was significantly (P≤0.01) higher under the almost cold weather period (7.43 kits) than that under the almost hot weather period (6.54 kits). The same trend was observed for the litter number per doe being 4.40 versus 3.44 for the aforementioned periods respectively. The highest significant (P≤0.01) number of fattening kits at the end of fattening period

/ doe was observed under the almost cold weather period (26.70 kits) comparable to that under the almost hot weather period (17.37 kits). The highest significant percentage of still-born mortality was detected during the almost hot weather period than under the almost cold weather period, being 8.54% versus 6.29% respectively. Concerning the weight at weaning, the almost cold weather period had the highest significant (P≤0.01) weight (526.94 gm) compared to that under the almost hot weather period (463.13 gm). The fertility percentage was 80.91% and 63.14% under the aforementioned periods respectively. All the previous differences were statistically significant (P≤0.01) as the survey results showed that the number of weaning kits / doe/years was 28.70 kits and 18.73 kits under the almost cold weather period and the almost hot weather period, respectively.

Table (3): Performance of rabbits (LSM ± SE) under the two main seasons of the year.

Items	Almost cold weather period	Almost hot weather period
Litter size at birth	7.43±.15 [a]	6.54±.10 [b]
Litter number in season	4.40±.07 [a]	3.44±.07 [b]
still-born mortality %	6.29±0.47 [b]	8.54±0.47 [a]
Mortality percentage of kits	8.14±1.17 [b]	11.78±1.17 [a]
Number of the fattening kits at the end of fattening period / doe	26.70±.65 [a]	17.37±.65 [b]
Age at weaning (days)	29.94±.33 [b]	31.70±.33 [a]
Weight at waning (g)	526.94±14.48 [a]	463.13±14.54 [b]
Mortality % of the fattening kits (at selling age)	7.13± 0.86	8.83±0.86
Marketing weight (g)	1856.35±32.02 [a]	1723.34±32.04 [b]
Fattening period (days)	54.76±1.99 [b]	62.27±1.98 [a]
Marketing age (day)	83.78±2.29 [b]	93.75±2.28 [a]
Doe mortality %	7.28±1.65	7.10±1.65
Number of weaning kits /doe/years	28.70±.62 [a]	18.73±.62 [b]
Gestation period (days)	31.19±.26	31.56±.26
Fertility percentage	80.91±1.72 [a]	63.14±1.73 [b]
Average value of THI	15.8 ±1.9	25.7 ± 1.2
Maximum value of THI	22.9	28.2
Minimum value of THI	10.8	20.07

[a,b] Means within the same row having different superscripts differ significantly (p≤0.05).

The data shown in Table (3) indicated that the changes in the minimum values (20.07 and 10.8) and maximum values (28.2 and 22.9) of THI for almost hot and almost cold period respectively, were high (Table 3). It could be concluded that the almost cold season with an average THI of 15.8 ±1.9 was a better season for litter size, litter number, number of weaning kits, number of fattening kits and weight at weaning as compared to the almost hot season with an average THI of 25.7 ± 1.2 as shown in Table (3). Similarly, Jaén-Téllez *et al.* (2021) indicated that rabbits were more productive in the cold season and temperature-humidity index significantly affected rabbit's average daily gain and daily feed intake. According to a number of several studies, In January, Baladi Red's largest litter size weight was noted. This might be as a result of the nutrient- and climatically beneficial conditions of this month (Abdel-Azeem *et al.*, 2007). Khalil (1994) interpreted this to increased milk supply production throughout the winter. However, summertime temperature stress and feed intake reduction had a severe impact on the fetal survival rate (from implantation to delivery), which in turn reduced the overall number of births. High ambient temperature causes rabbit does to consume less feed hence, reduction in litter size occurred in May and June (Sallam *et al.*, 1999). Rabbits are extremely sensitive to heat stress, which is linked to decreased, feed intake, feed efficiency and body weight gain (Farghly *et al.*, 2020). Rabbits exposed to heat stress undergo a certain physiological change which resulted in a significant decrease in weight for slaughter, carcass, and organs (Zeferino *et al.*, 2011). Heat stress has an impact on rabbit growth (Marai *et al.*, 2001 and 2002; Okab and El-Banna 2003; Okab *et al.*, 2008; Ondruska *et al.*, 2011). The post-natal growth rate of kits from heat-stressed does was lower during nursing (Marco-Jiménez *et al.*, 2017). Sivakumar *et al.* (2013) litter weight at birth and weaning, average weight of kits at birth and weaning were affected by season of birth. The availability and quality of foods, as well as the meteorological seasonality, all had an impact on the litter size's response to kindling season (Youssef, 1992).

3.3 Impact of the interaction on rabbit's productivity

Table (4) showed the performance of rabbits as affected by the interaction between production system and the period of the year. It was obvious that the highest number of litter size at birth was found under the semi-commercial system under the almost cold weather period (with an average THI of 15.8 ±1.9) being 8.12 however the lowest number of litter size at birth was detected under the family system with the almost hot weather period (with an average THI of 25.7 ± 1.2) being 6.07. The highest number of weaning kits/doe/years was observed under the semi-commercial and commercial system with the almost cold weather period (average THI of 15.8 ±1.9) being 31.90 and 31.78 respectively, while the lowest number was found under the family system with the almost hot weather period (an average THI of 25.7 ± 1.2) being 13.38. The same trend was observed for the number of fattening kits at the end of fattening period / doe being 29.88 and 29.73 versus 12.61 for the commercial and semi-commercial systems with the almost cold weather period versus the family system with the almost hot weather period. All the previous differences were statistically significant ($P \leq 0.01$). Regarding the marketing weight, it was evident that the best weight was under the semi-commercial system (1919.05 gm) and commercial system (1889.13gm) with the almost cold weather period and the worst weight was under the family system (1604.95gm) with the almost hot weather period. Concerning the fertility percentage, it was evident that the best fertility percentage was under the commercial system (84.77%) and semi-commercial system (82.20%) with the almost cold weather period and the worst fertility percentage was under the family system (53.96 %) with the almost hot weather period as shown in Table (4).

Table (4): Performance of rabbits (LSM ± SE) as affected by the interaction between production system and the season of the year.

Items	S1*C1	S1*C2	S2*C1	S2*C2	S3*C1	S3*C2
Litter size at birth	6.39±.10 ^{c}	6.07±.10 ^{c}	8.12±.17 ^{a}	6.45±.17 ^{c}	7.78±.23 ^{a}	7.09±.23 ^{b}
Litter number	4.11±.07 ^{b}	2.91±.07 ^{d}	4.52±.11 ^{a}	3.40±.11 ^{c}	4.57±.15 ^{a}	4±.15 ^{b}
still-born mortality %	5.75±.48 ^{b}	7.70±.48 ^{b}	7.23±.80 ^{b}	10.39±.80 ^{a}	5.89±1.08 ^{b}	7.52±1.08 ^{b}
Mortality percentage of kits	12.48±1.18 ^{b}	18.56±1.18 ^{a}	6.12±1.97 ^{c}	9.80±1.97 ^{bc}	5.82±2.66 ^{c}	6.96±2.66 ^{bc}
Number of the fattening kits at the end of fattening period / doe	20.50±.66 ^{b}	12.61±.66 ^{d}	29.73±1.09 ^{a}	16.10±1.09 ^{c}	29.88±1.47 ^{a}	23.41±1.17 ^{b}
Age at weaning (days)	29.99±.35 ^{bc}	31.50±.35 ^{ab}	28.88±.56 ^{c}	31.52±.56 ^{b}	30.96±.75 ^{ab}	32.9±.75 ^{a}
Weight at waning (g)	384.40±20.79 ^{c}	341.98±21.22 ^{c}	546.43±22.68 ^{b}	495.24±22.68 ^{b}	650±30.65 ^{a}	552.17±30.65 ^{b}
Mortality % of the fattening kits (at selling age)	7.6±.87 ^{b}	8.06±.87 ^{b}	7.13±1.44 ^{b}	12.70±1.44 ^{a}	6.63±1.94 ^{b}	5.73±1.94 ^{b}
Marketing weight (g)	1760.87±35.82 ^{ab}	1604.95±36.01 ^{b}	1919.05±53.01 ^{a}	1810.71±53.01 ^{a}	1889.13±71.64 ^{a}	1754.35±71.64 ^{ab}
Fattening period (days)	70.64±2.21 ^{b}	82.34±2.19 ^{a}	52.98±3.30 ^{d}	60.60±3.30 ^{c}	40.65±4.46 ^{e}	44.87±4.46 ^{de}
Marketing age (day)	97.87±2.55 ^{b}	112.19±2.51 ^{a}	81.86±3.79 ^{c}	92.12±3.79 ^{b}	71.61±5.12 ^{c}	76.96±5.12 ^{c}
Doe mortality %	2.89±1.66 ^{b}	5.90±1.66 ^{b}	4.80±2.78 ^{b}	10.36±2.78 ^{ab}	14.15±3.75 ^{a}	7.73±3.75 ^{ab}
Number of weaning kits / doe/years	22.43±.63 ^{b}	13.38±.63 ^{d}	31.90±1.05 ^{a}	18.05±1.05 ^{c}	31.78±1.41 ^{a}	24.76±1.41 ^{b}
Gestation period (days)	32.67±.28 ^{a}	32.30±.28 ^{a}	30.18±.42 ^{c}	30.95±.42 ^{bc}	30.71±.58 ^{bc}	31.43±.58 ^{b}
Fertility percentage	75.76±2.41 ^{a}	53.96±2.49 ^{c}	82.20±2.69 ^{a}	63.41±2.69 ^{c}	84.77±3.67 ^{a}	72.05±3.67 ^{b}

S1 (Family system), S2 (Semi-commercial system), S3 (Commercial system), C1 (Almost cold weather period), C2 (Almost hot weather period), ^{a,b,c}Means within the same row having different superscripts differ significantly ($p \leq 0.05$).

4. Conclusion

The commercial and semi-commercial systems exhibited the highest significant litter size and weight of weaning and fattening kits, and fertility percentage as compared to the family systems. Moreover, the almost cold weather period exhibited the best productive and reproductive performance of rabbits.

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