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REPRODUCTIVE EFFICIENCY OF FEMALE GERMAN ANGORA RABBITS UNDER INDIAN SUB-TEMPERATE CLIMATIC CONDITIONS

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ABSTRACT: The influence of season, parity, age and weight of doe at service on the reproductive efficiency of female German Angora rabbits has been studied. Nulliparous German Angora rabbits of 4 - 5 months of age were imported from Germany in August, 1997 and reared under standard management practices. They subjected to an extensive breeding system (re-mating after weaning). The kits were weaned 42 days after kindling. The data from the reproduction records of 149 does, consisting of 398 matings and 238 kindlings during a period of five years, (1998 to 2002) were analyzed. The parameters considered were fertility rate, litter size at birth (LSB), litter weight at birth (LWB), litter size at weaning (LSW), gestation length and sex ratio. The overall fertility percentage, LSB, LWB (g), LSW (g), gestation length (d) and sex ratio percentage were 61.18, 4.89, 253.88, 4.44, 31.95 and 53.94, respectively. The season of the year had a significant ($P \leq 0.05$) effect on LSB, LWB, LSW and gestation length, with higher values of LSB, LWB and LSW in spring. The fertility rate was significantly higher ($P \leq 0.05$) for the females of 1 to 2 years of age. Spring appears to be the most favorable season for efficient reproduction of German Angora rabbits under the sub-temperate climatic conditions found in India.

Key words: fertility, rabbit, season, parity, German angora, reproductive efficiency.

INTRODUCTION

Angora rabbit farming is a profitable business for the production of fine quality wool used in making warm clothes such as shawls, thermal underwear, caps, etc. As the level of production directly depends on the rate of reproduction, the reproductive efficiency of rabbits becomes an important aspect in determining the profitability of commercial rabbitries. Factors such as season, parity, age and weight of females

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influence the reproductive efficiency of the animals. There is a lack of accurate information on the reproductive efficiency of German Angora rabbits under Indian conditions. This being the case, there is a need to evaluate the influence of these factors in order to improve the reproductive performance of these rabbits in the future. The present study was undertaken in order to determine the influence of these variables on the reproductive efficiency of female German Angora rabbits under the sub-temperate climatic conditions found in India.

MATERIALS AND METHODS

Nulliparous German Angora rabbits of 4 - 5 months age were imported from Germany in August, 1997. They were reared under the standard management practices for sub-temperate climatic conditions of the angora rabbit unit of the North Temperate Regional Station of the Central Sheep and Wool Research Institute, Garsa, Kullu (HP), India. The station is located at longitude 32^0 N, latitude 78^0 E and is at a height of 3976 feet above mean sea level.

All the does were individually kept in standard size iron cages and were provided similar housing and management throughout the study period. They were fed with a concentrate 140 g/d (280 g/d during lactation) in pellet form and seasonal roughage and water *ad libitum*. The concentrate diet was composed of maize 30%, groundnut expeller 20%, sunflower-cake 5%, soyflakes 5%, wheat bran 15%, rice bran 15%, fishmeal 3.5%, molasses 5%, mineral mixture 1% and common salt 0.5%. Additionally, the feed (100 kg) was supplemented with 100 mg/kg of vitamins A-D_3, K and E with selenium mixture; 50 mg/kg of lysine and 50 mg/kg of methionine; 500 mg/kg of magnesium oxide and 2.5 g/kg of di-calcium phosphate. Seasonal roughage consisting of dried *Festuca arundinacea*, *Lolium perenae*, *Trifolium repens*, *Paspalum* spp., or *Setaria* spp. was supplied in the afternoon.

The imported German Angora females (n=37) were first mated at 10-11 months of age while their progeny (n=112) were first mated at 7-8 months of age, and thereafter a semi-intensive breeding system (re-mating after weaning) was followed.

The mating was suspended in the winter season (December to February) since the temperature at this time is too low for the survival of kits under the housing conditions described. Mating programme was carried out to avoid inbreeding (one buck for three does). The culling of breeding females was based on their reproductive performance, including acceptance by the male, three consecutive failures to conceive, and litter size. The breeding does were selected on the basis of body weight, wool yield and quality at the second shearing (125 days of age). The first shearing was manually performed at 50 days of age (after 8 days of weaning) and subsequently at 75-day intervals.

Newborn kits were milk-fed twice a day, morning and evening. Twenty days after birth, they were offered mashed concentrate diet until weaning. The young were weaned at 42 days of age. The weanling rabbits were sexed and kept individually in all-wire mesh cages under similar housing and management conditions. Each weanling received concentrate (50 g/d from 42 to 84 days and 80 g/d from 85 to 165 days) in pellet form, roughage and water *ad libitum.*

Monthly meteorological data including minimum and maximum temperature (^{0}C), relative humidity (%) and rainfall (mm) were collected from the records of the station and used to define the seasons, i.e. winter (December to February), Spring (March to May), Summer (June to August) and Autumn (September to November).

The data from the records on reproduction of 149 does, consisting of 389 matings and 238 kindlings for the 5-year period (1998 to 2002) were analyzed to study the effect of season of kindling (spring, summer, autumn), parity (1st to 4th), live weight of doe at service (< 3.5 kg and > 3.5 kg) and age of doe at service (6 month – 1 yr, 1-2 yr and > 2 yr) on reproductive efficiency. The parameters of reproductive efficiency considered were fertility rate, prolificacy (litter size at birth and weaning), litter weight at birth, gestation length and sex ratio (percentage of males).

The data were analyzed by analysis of variance (ANOVA) using the general linear model (GLM) procedure of SPSS 10.0 for Windows 98 with different fixed effects: season, parity, age and live weight. The fertility rates were compared using the chi square test defined by SNEDECOR and COCHRAN, 1994.

RESULTS AND DISCUSSION

The results are presented as means, standard error means and percentage. The ambiental and meteorological conditions during the different seasons are depicted in Figure 1. The average temperature was 10.34 ± 3.27, 19.34 ± 3.64, 25.57 ± 2.36 and 19.57 ± 3.97 ^{0}C during winter, spring, summer and autumn , respectively. The average relative humidity and total rainfall were 70.12 ± 1.11 per cent and 43.70 ± 19.21 mm, 61.01 ± 2.36 per cent and 41.24 ± 11.00 mm, 72.73 ± 3.08 per cent and 111.18 ± 15.13 mm and 74.3 ± 1.25 per cent and 60.01 ± 32.94 mm for the respective seasons. The overall value of fertility and mean values as influenced by season of kindling, parity, age and live weight of doe at service are presented in Table 1. The corresponding values for litter size at birth (LSB), litter weight at birth (LWB), litter size at weaning (LSW), gestation length and sex ratio are depicted in Table 2. The overall fertility rate, LSB, LWB, LSW, gestation length and sex ratio were 61.18 per cent, 4.89 ± 0.19, 253.88 ± 10.79 g, 4.44 ± 0.22, 31.95 ± 0.15 d and 53.94 ± 3.1 per cent, respectively.

Season of kindling significantly ($P \leq 0.05$) affected LSB, LWB, LSW and gestation length, whereas it was observed to have no significant effect on fertility rate and sex ratio. In accordance with our findings, the non-significant effect of season on fertility (RODRIGUEZ and FALLAS, 1999) and sex ratio (KHALIL and MANSOUR, 1987) has been reported earlier. Whereas PONCE de LEÓN *et al.* (2000) have observed season to have a significant effect on fertility rate, reporting it higher in spring and lower in autumn. LSB, LWB and LSW were seems to be higher in spring, followed by autumn, and lowest in summer, indicating that spring is the best season for rabbit breeding in India. KHALIL and MANSOUR (1987) also noted significantly higher values for LSB, LWB and LSW in spring. EL-MAGHAWRY *et al*. (1988) reported significantly higher LSB and LWB in spring, but they found no significant effect of season on LSW.

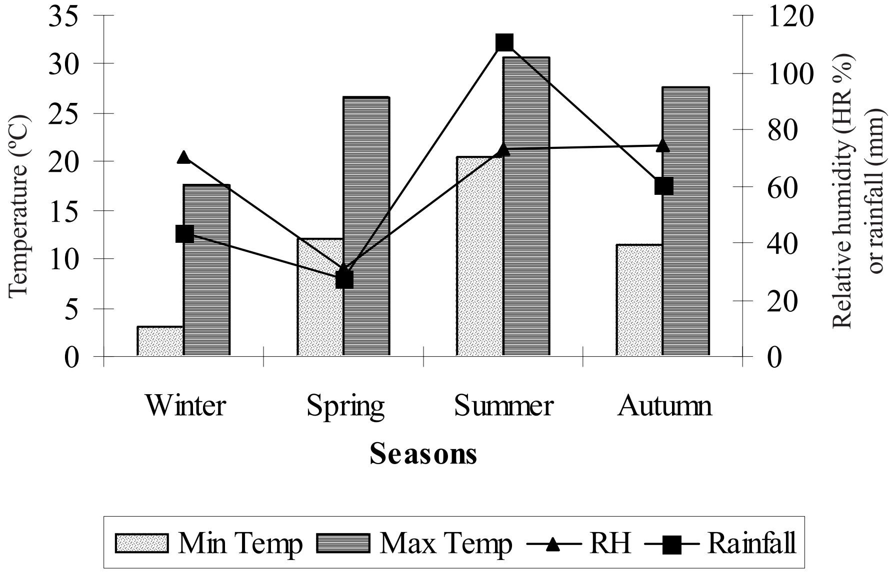

Figure 1: Ambiental and metereological attributes during different seasons.

Other authors have observed no significant effect of season on LSB, LWB and LSW (BHATT *et al.* 2002). BELHADI *et al.* (2002) also support our findings that spring is the best season for reproduction of rabbits. Summer has been reported as an unfavorable season in both temperate (GARCIA *et al.* 2000) and tropical (PONCE de LEON *et al.* 2000) climates for breeding rabbits.

Gestation length was significantly ($P \leq 0.05$) lower during autumn (31.38 ± 0.27) compared to spring (32.02 ± 0.22) and summer (32.57 ± 0.30). In agreement with our findings, KHALIL and MANSOUR (1987) reported a significant, although irregular effect of month of kindling on gestation length in Bauscat rabbits.

The influence of season observed in this study on reproductive efficiency may be attributed to changes in the photoperiod (HUDSON and DISTEL, 1990) and/or temperature (SIMPLICIO *et al.* 1988). The increase in day length, a comfortable temperature and the availability of a good roughage supply during spring may contribute to the high reproductive efficiency of rabbits in this season. Another reason for the comparatively better reproductive performance during spring may be a result of the rest period given to does during winter. On the other hand, the comparatively

Table 1: Effect of season, parity, doe age and live weight on fertility of German Angora rabbits.

Factors	No. of doe	No. of mating	No. of kindling	Fertility rate (%)
Overall	149	389	238	61.18
Season				
Spring	141	267	163	61.05
Summer	44	54	33	61.11
Autumn	53	68	42	61.76
Parity				
1st	149	213	127	59.6
2nd	78	97	69	71.13
3rd	32	50	26	55.32
4th	13	22	10	45.5
Age				
½ to 1 year	107	161	94	58.39[a]
1 to 2 years	117	170	117	68.82[b]
> 2 years	33	58	28	48.28[a]
Live weight				
< 3.5 kg	99	176	109	61.93
> 3.5 kg	99	213	129	60.56

Means within a column with different superscripts differ. ($P<0.05$).

high temperature and humidity (Figure 1) in the summer might have influenced the metabolic and hormonal status of does and had a carry- over effect that greatly reduced reproduction (TRAMMELL *et al*. 1989). Also, rabbits are susceptible to heat stress due to the fact that they have few functional sweat glands (CHECKE *et al.* 1987) and their feed and water intake decreases as temperature and humidity increase (HAFEZ, 1970), which has an indirect effect on fertility and prolificacy. The adverse effects of high

Table 2: Means and standard error (mean ± SE) of effect of season, parity, age and weight on reproductive parameters.

Factors	LSB	LWB (g)	LSW	Gestation length (days)	Sex ratio (%)
Overall	4.89 ± 0.19	253.88 ± 10.17	4.44 ± 0.22	31.95 ± 0.15	53.94 ± 3.1
Season					
Spring	5.23 ± 0.29[a]	283.17 ± 15.98[a]	4.84 ± 0.32[a]	32.02 ± 0.22[a]	53.41 ± 4.59
Summer	4.16 ± 0.38[b]	198.89 ± 21.36[b]	3.54 ± 0.43[b]	32.57 ± 0.30[a]	55.06 ± 6.1
Autumn	5.08 ± 0.35[ab]	264.67 ± 19.54[a]	4.71 ± 0.39[a]	31.38 ± 0.27[b]	53.63 ± 5.62
Parity					
1st	4.47 ± 0.31	223.85 ± 17.34	4.01 ± 0.35	32.40 ± 0.24	62.13 ± 4.98
2nd	5.00 ± 0.34	274.46 ± 19.14	4.29 ± 0.38	32.06 ± 0.26	48.22 ± 5.50
3rd	5.14 ± 0.42	264.69 ± 23.70	4.70 ± 0.47	31.79 ± 0.33	51.68 ± 6.81
4th	4.71 ± 0.62	222.08 ± 34.91	4.50 ± 0.69	31.46 ± 0.48	54.83 ± 10.04
Age					
½ to 1 year	4.56 ± 0.04	236.36 ± 22.48	4.10±0.45	32.17 ± 0.31	60.50 ± 6.46
1 to 2 years	5.25 ± 0.24	274.13 ± 13.15	4.56 ± 0.26	31.87 ± 0.18	50.88 ± 3.78
> 2 years	4.68 ± 0.37	241.41 ± 20.57	4.47 ± 0.41	31.94 ± 0.28	54.08 ± 5.91
Weight					
<3.5 Kg	4.84 ± 0.31	249.41 ± 17.61	4.56 ± 0.35	31.90 ± 0.24	60.15 ± 5.06
>3.5 Kg	4.93 ± 0.24	256.97 ± 13.60	4.36 ± 0.27	31.99 ± 0.19	49.64 ± 3.91

LSB: litter size at birth, LWB: litter weight at birth, LSW: litter size at weaning.
Means within a column with different superscripts differ. (P<0.05).

temperature on spermatogenesis (OLOUFA *et al.* 1951), fertilization failure (RICH and ALLISTON, 1970) and embryonic mortality (HOWARTH *et al.* 1965) have also been established.

The reproductive parameters at 5th and 6th parity were not comparable due to the very low number of kindlings, hence the results pertaining to these parities are not given or discussed here. The influence of parity order was non-significant on all the parameters studied. The non-significant effect of parity on reproduction in rabbits has also been reported (Garcia *et al.* 2000). However, El-Magawry *et al.* (1988) observed significant differences among parities in LSB and LSW. The fertility rate, LSB and LWB values were higher at 2nd parity and then gradually decreased to 4th parity, whereas, LSW was highest at 1st parity and declined with parity number. These results agree with previous reports, which indicate that conception rate (as mentioned by Belhadi *et al.* 2002) and LSB (Lavara *et al.,* 2000) could increase up to 2nd parity and decreases thereafter. However, few authors observed the highest conception and kindling at the 1st parity (Rodriguez and Fallas, 1999 and Belhadi *et al.* 2002) as well as LSB (El-Magawry *et al.* 1988).

LSB, LWB and LSW values were higher in the females of 1-2 years of age, followed by females of more than 2 years and less than 1 year of age. However, significant ($P \leq 0.05$) differences were only observed for fertility rate, being females of 1 to 2 years those with better fertility rate. In disagreement with these findings, Aumann *et al.* (1984) reported a highly significant effect of age on LSB. The age of the female at service had no significant effect on gestation length and sex ratio. In agreement with our findings, Larson and Foote (1972) have mentioned a possible decrease in reproductive efficiency in older females with advancing age. The decrease in reproductive efficiency with increasing maternal age has been attributed to uterine ageing (Adams, 1970), inadequate environment (Maurer and Foote, 1971) and a reduced rate of uterine flow (Larson and Foote, 1972). The live weight of the doe at mating had no significant effect on fertility rate, LSB, LWB, LSW, gestation length and sex ratio. El-Magawry *et al.* (1988) also reported no significant effect of doe weight at service on LSB, LWB and LSW.

The inconsistencies in the influence of these factors on reproductive efficiency among the studies cited above can be attributed to differences in the breeding systems, particularly in reproduction rate, housing, feeding, climate and the breed / genotype used. In view of the importance of these factors in the reproductive efficiency of female German Angora rabbits, the consideration of their effects at the time of breeding can help to improve reproductive efficiency and consequently production.

In conclusion, the results of the present study indicate that spring appears to be the most favorable season for the efficient reproduction of Angora rabbits under the sub-temperate climatic conditions found in this region of India.

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