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Non-genetic influences on growth performance of a population of farm-bred New Zealand White rabbits

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Abstract— **The study was carried out to analyze the effect of different non-genetic factors influencing the growth performance New Zealand White rabbits under farm conditions. The traits included were body weights at different ages (weaning and post-weaning up to marketing) and average daily gains at different age intervals (weaning to 70 days, 70 days to 135 days and weaning to 135 days as ADG1, 2 and 3, respectively). The non-genetic factors considered for the study were sex of the kit, season and period of birth the kits. The average weight at weaning, 70 days and 135 days were 0.715, 1.276 and 2.187 kg respectively. The average daily gains were 19.762, 13.482, 15.490 g for ADG1, ADG2 and ADG3, respectively. The body weight traits as well as average daily gains were highly significantly (P<0.01) influenced by the season and period of birth of the kits. The sex of the kit did not significantly influence any of the traits except ADG1. The results and the possible causes were also discussed.**

Index Terms— ***Average daily gain, growth efficiency, New Zealand White rabbit, non-genetic factors***

I. INTRODUCTION

Rabbit rearing gained momentum in the recent past among the developing countries including India, owing to their high prolificacy, early maturity, shorter generation interval and efficiency in feed utilization. In India, it has been realized that domestic rabbit is an important livestock species which has immense potential to improve the socio-economic status of the rural poor and to contribute substantially to the country's Gross Domestic Product (GDP) as well [1]. Rabbit meat is a lean meat rich in proteins of high-biological values, with highly unsaturated lipids, low cholesterol content, noticeable quantities of linolenic fatty acid and a good source of B vitamins [2]. Hence, the genetic improvement of rabbits is very much needed on the way to increase their contribution to the much needed animal protein in developing countries [3].

Formulation of breeding strategies require accurate values of genetic parameters, for which precise estimates of (co)variance components, obtained after adjustment for various non-genetic factors are a pre-requisite.

The New Zealand White breed of rabbit is one of the most commonly used exotic breeds in India. They are reared irrespective of the geographical locations and available in almost all parts of the country. This breed adapts well in India and needs to be improved upon under the local environment through scientific selection and breeding which is also necessary for preventing genetic degradation in live body weight [4].

Compared with most farm animals, the information on factors affecting growth rates in rabbits is scanty. Hence, the present study was undertaken to analyze the various non-genetic factors affecting the growth parameters in a population of New Zealand White rabbit.

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II. MATERIAL AND METHODS

A. Animals and Location of the study

The study was carried out on a closed population of New Zealand White rabbits maintained at the farm of Sheep Breeding Research Station, Sandynallah, Ooty, Tamil Nadu. The farm is situated at an altitude ranging from 2090 to 2235 m above mean sea level at Nilgiri hills which is the meeting point of Western and Eastern ghats of south India. The mean minimum and maximum temperatures recorded were 12.2° and 19.2°C respectively and the range was from 8.5°C in January to 22.1°C in April. Sub-zero temperatures are also recorded on individual days during winter. The relative humidity averaged 80 per cent in the mornings and 60 per cent in the evenings. The New Zealand White rabbits were maintained by pure breeding. The flock was a closed type where 40 to 60 breeding females were maintained every year with the male to female ratio of 1:5.

B. Management

1) Housing: The rabbits were maintained in cage system of rearing. The male and females were housed in individual galvanized iron cages with the dimension of 2' x 1.5' X 1.5' kept 3 feet above from the ground level in steel stands. Air circulation in the rabbitary was ensured by providing exhaust fans. Nest boxes were provided in pregnant rabbits cages at 23-25 days of gestation. Nest boxes were inspected every 6 hours during day time any dead kits. The nest boxes were provided till the kits are 4 weeks old. Weaning of kits was carried out at 42 days.

2) *Feeding:* The rabbits were fed with concentrate mash feed (16 per cent crude protein and 2500 kcal digestible energy) every morning at the rate of 75 g per day up to 6^{th} week of age and 100 g per day from 7^{th} to 12^{th} week of age. For the lactating does and kits, a concentrate mixture of 150 to 200 g per day was given according to their body weight and litter size. Additionally, the rabbits were fed with green fodder viz., kikiyu (*Pennisetum clandestinum)* with white clover in the afternoon at the rate of 250 to 300 g per animal, according to their body size. Clean warm

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potable water was supplied for drinking and the water availability was ensured all the time. During winter months, because of severe frost, the rabbits were fed with oats, tree Lucerne, carrots and *Phalaris aquatica* grass.

3) *Breeding:* The rabbits were first bred at the age of 5 to 6 months of age. They were bred 6 weeks after the parturition, thereafter. Bucks start their reproductive lives at 5 months of age and the does at 6 months of age. Bucks were randomly assigned to females for natural service. Mating of close relatives was avoided as far as possible to keep the inbreeding at its lower level. Hand mating was the preferred method of breeding the rabbits.

4) *Selection and Culling:* Initially, the animals were under selection for growth as well as reproductive traits. Of late, selection was oriented towards body weight alone. The usual selection pressure applied was 2-5 per cent and 10-20 per cent for males and females, respectively. Does were culled after 3 years of age and bucks were culled after 2 years of age.

5) *Health coverage:* A standard prophylactic schedule of endo- and ecto- parasitic control besides symptomatic treatment was adopted for the control of various diseases. All growers were drenched with anticoccidials every 15 days until they are 4 months of age and adults were drenched with anticoccidials on need basis.

C. Traits studied

1) *Body weight at different ages:*
Body weight in kilograms at weaning (W42), 70 days (W70), and 135 days (W135) of age were considered for the study.

2) *Average Daily Gain at different age intervals (ADG):*
Average daily gain in grams (ADG) is the change in size over time. The ADG in g/day was calculated as:

$$ADG = (y_{t2} - y_{t1}) / (t_2 - t_1)$$

Where, y_{t1} and y_{t2} refer to body weights at t_1 and t_2 ages in days respectively [5].

The age intervals studied for the average daily gain were weaning to 70 days, 70 days to 135 days and weaning to 135 days and denoted as ADG1, ADG2 and ADG3, respectively.

D. Data collection and statistical analysis

The data were collected from the growth records for a period of 15 years from 1998 to 2012. The individual animal identity, sire, dam, date of birth, sex, weight at weaning, weight at 70 days and weight at marketing were collected. Sex of kit, season and period of birth of the individual were the various non-genetic sources of variation studied. According to the agro-climatic condition prevailing in the study area, the year was divided into four seasons (four levels) namely winter (December to February), summer (March to May), south-west monsoon (June to August) and north-east monsoon (September to November). The year of birth was grouped into five periods of three years each (five levels). Abnormal records of animals that died due to disease or those with progressive weight loss were kept as outliers. Single trait analyses were done by fitting a general linear model (GLM) to study the effect of various non-genetic factors on each trait.

The model used for the analysis was as follows:

$$Y_{ijkn} = \mu + X_i + Y_j + Z_k + e_{ijkn}$$

Where,

Y_{ijkm} being the growth trait of the n^{th} animal belonging to i^{th} sex, j^{th} season and k^{th} period; μ being the overall mean; X_i being the effect of i^{th} sex, Y_j being the effect of j^{th} season, Z_k being the effect of k^{th} period and e_{ijkn} being the random error associated with each observation, NID $(0,\sigma^2_e)$.

All the factors were included as fixed effects in the statistical analysis. The data were analyzed using the statistical software package SPSS version 20.0. The differences between the least-squares means for subclass under a particular effect were tested by Duncan's multiple range tests.

III. Results

The results of single trait least-squares analysis of various body weight traits are presented in Table I. The mean body weights at 42 days, 70 days and 135 days were 0.715, 1.276 and 2.187 kg, respectively. The season and period of birth had highly significant ($P<0.01$) influence on all the body weight traits studied whereas the sex of the kit did not have any significant effect on any of the body weight traits.

TABLE I. Least squares means (±SE) of body weight traits (kg)

Details	W42		W70		W135	
	N	Mean	N	Mean	N	Mean
Overall mean	2450	0.715±0.004	1837	1.276±0.006	901	2.187±0.011
Sex		NS		NS		NS
Male	1197	0.710±0.005	980	1.280±0.008	528	2.185±0.014
Female	1253	0.720±0.005	857	1.273±0.008	373	2.189±0.016
Season		**		**		**
South-west monsoon	579	0.705^a±0.007	456	1.220^a±0.011	267	2.078^a±0.020
North-east monsoon	547	0.725^a±0.008	422	1.291^b±0.012	175	2.246^b±0.022
Winter	521	0.731^b±0.007	379	1.337^c±0.012	187	2.300^b±0.024
Summer	803	0.700^a±0.006	580	1.258^b±0.010	272	2.125^a±0.019
Period		**		**		**
1998-2000	443	0.664^{ab}±0.008	304	1.276^b±0.014	130	2.207^b±0.026
2001-2003	417	0.795^c±0.008	299	1.375^c±0.014	119	2.359^c±0.028
2004-2006	429	0.795^c±0.009	361	1.354^c±0.013	225	2.019^a±0.021
2007-2009	567	0.681^b±0.007	407	1.198^a±0.012	194	2.160^b±0.023
2010-2012	594	0.642^a±0.007	466	1.179^a±0.011	233	2.192^b±0.020

** P<0.01; NS – Not significant; Subclass means with different superscripts are significantly different from each other; N=Number of observations

The least-squares means of average daily gain for various age intervals are presented in Table II. The maximum ADG was observed from weaning to 70 days of age (19.762 g) and the least gain was noticed during the period from 70 days to 135 days of age (13.482 g). The season and period of birth had highly significant ($P<0.01$) influence on all the three traits whereas the sex of the kit had significant ($P<0.05$) influence on ADG1 only.

TABLE II. Least squares means (±SE) of Average Daily Gain (g)

Details	ADG1		ADG2		ADG3	
	N	Mean	N	Mean	N	Mean
Overall mean	1834	19.762±0.156	900	13.482±0.150	901	15.490±0.107
Sex		*		NS		NS
Male	978	20.134±0.212	528	13.598±0.196	528	15.699±0.140
Female	856	19.389±0.229	372	13.366±0.227	373	15.281±0.162
Season		**		**		**

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South-west monsoon	454	18.159^{a}±0.313	267	12.835^{a}±0.279	267	14.516^{a}±0.200
North-east monsoon	422	19.733^{b}±0.327	175	13.902^{b}±0.313	175	15.888^{b}±0.224
Winter	379	21.214^{c}±0.335	187	14.325^{c}±0.333	187	16.442^{b}±0.238
Summer	579	19.939^{b}±0.269	271	12.868^{a}±0.269	272	15.113^{a}±0.192
Period		**		**		**
1998-2000	304	21.028^{c}±0.370	130	13.650^{b}±0.364	130	15.898^{b}±0.260
2001-2003	298	20.743^{c}±0.376	119	14.488^{c}±0.400	119	16.544^{b}±0.286
2004-2006	359	19.772^{b}±0.362	224	9.948^{a}±0.290	225	12.990^{a}±0.207
2007-2009	407	18.704^{a}±0.330	194	14.474^{c}±0.319	194	15.779^{b}±0.228
2010-2012	466	18.561^{a}±0.301	233	14.853^{c}±0.287	233	16.238^{b}±0.205

** P<0.01; * P<0.05; NS – Not significant; Subclass means with different superscripts are significantly different from each other; N=Number of observations

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IV. DISCUSSION

The body weight traits studied were weight at 42 days (W42), 70 days (W70) and 135 days (W135). At 42 days, the kits are weaned from the influence of its mother. Among the post-weaning weights, W70 is the first measurable trait, and on account of its better heritability, is normally recommended as a selection criterion to improve the market weight. The W135 is important because marketing age is normally 20 weeks in most of the broiler rabbits. Rabbits, in general are allowed for mating at 22 to 26 weeks (5 to 6 months) of age. Weight at this age is important, as the animals are presumed ready for breeding only they attain at least 2/3rd of the mature body weight.

The mean body weight at weaning was observed to be 0.715 kg which is comparable with the earlier reports on various breeds of rabbits. The range of valued reported for weaning weight in New Zealand White rabbit was 0.45 to 0.95 kg [6]–[12]. The values reported for the crossbreds involving this breed were within the range of 0.41 to 1.13 kg [13]–[17]. The present finding is comparable with the values reported for the breed by several authors. It is to be noted that the weaning was practiced at 42 days only in certain countries including India whereas in most of the reports from tropical countries it was 28 days. Among the rabbit breeds, New Zealand White is superior in weaning weight barring certain inbred lines of rabbits which is evident from the available reports. Anous et al. (1999) reported 0.95 kg at 28 days of weaning which shows the high potential of this breed in growth traits. In fact, the weight at 42 days is comparatively lesser than the reports of the breed elsewhere. The accumulated rise in inbreeding due to the closed nature of the farm could be one of the factors responsible for the decline in weaning weight.

In the present study, the mean post-weaning body weights at 70 days and 135 days of age were 1.276 kg and 2.187 kg, respectively. These values are comparable with the earlier reports on this breed [6]–[12]. The mean value of post-weaning weight for New Zealand White rabbits ranged from 1.01 kg to 2.07 kg. The values reported for the crossbreds involving New Zealand White rabbits were 1.35 – 1.43 kg [14]–[17]. Although the present finding was within the range of valued reported for the breed, the marketing age practiced in the present study was 20 weeks of age whereas it was 12-16 weeks in the available reports. Therefore, the present finding of post-weaning weight are comparatively lesser which can be attributed to the accumulated inbreeding over generations in the closed population.

Among the non-genetic factors, the season and period of birth showed highly significant effect on all the three body weight traits studied. The sex of the newborn kit had significant effect on none of these traits. In most of the earlier studies on rabbit, period, season and sex of the kit at birth were studied. The parity and weight of dam at kindling were other traits included in fewer studies. Due to non-availability of data on parity and weight of dam, these two factors could not be included in the present study.

In the present study, the kits born during winter season showed maximum body weights at all ages. This is can attributed to the high plane of nutrition available during winter months. The animals were fed additionally with oats, tree Lucerne, carrots and *Phalaris aquatica* grass. Among the period of birth, the kits born during the last period (2010 to 2012) had comparatively lesser body weights than other period. This can be attributed to the non-availability or poor availability of greed fodders due to the failure or poor rainfall during the period. Similarly, the higher body weights during the period from 2001 to 2003 might be due to good monsoon rain followed by lush green pasture.

The average daily gain for various age intervals in the present study are based on post-weaning weights only. The mean values of ADGs were found to be within the range of 13.482 to 19.762 g in the present study. An average post-weaning daily gain of 14.1 g and 29.0 to 33.0 g, respectively in New Zealand White rabbits were reported by [6] and [18]. The results obtained in the present study are comparable with that reported for other breeds of rabbits also. The post-weaning daily weight gain of 13.4 g in White Giant breed [19] and a range of 9.0 to 13.1 g for post-weaning average daily gain in Burundi local breed of rabbit [6] were also reported. However, higher ADG values compared with the present study were also reported in New Zealand White (71.6 g) and Californian rabbit (58.4 g) by [20]. Among the crossbreds involving New Zealand White, the reported ADG were within the range of 16.02 to 50.8 g as reported by several authors.

Among the non-genetic factors, season and period of birth has highly significant (P<0.01) influence on all the three ADGs whereas the sex of the kit had significant effect only on ADG1. The winter season yielded more beneficial values for rabbit performance in a sub-temperate climate, whereas summer temperature as well as heavy rainfall led to significant reduction (P<0.01) in average daily gain. Perhaps this is a reflection of the effect of season of kindling on milk production. The difference associated with the kindling season can be attributed to the prevalent environmental conditions and stress factors affecting feed intake. The period of birth had significant effects as that of body weight traits.

V. CONCLUSION

The present study revealed that the mean values of body weight traits and growth efficiency parameters in terms of average daily gains in the population under study were comparable with the reports of the New Zealand White rabbit elsewhere. Among the non-genetic factors, the body weight traits were highly significantly affected by the season and period of birth of kits. The sex of the kit did not significantly influence the growth performance. The average daily gains at

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different age intervals were highly significantly affected by the season and period of birth of kits whereas the sex of the kit significantly influenced only the immediate post-weaning weight in the population. These results can be useful in further genetic analysis of growth performance and to ensure better management strategies for the present population of New Zealand White rabbits.

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