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HERITABILITY AND NON GENETIC FACTORS FOR LIFETIME PRODUCTION TRAITS IN NEW ZEALAND WHITE RABBITS RAISED IN INTENSIVE SYSTEM OF PRODUCTION

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ABSTRACT

Data on 14210 litters of New Zealand White rabbits produced by 2945 does mothered by 1613 dams and fathered by 842 sires were analysed to characterize this breed for lifetime production traits and to estimate variance components and heritabilities of these traits. Lifetime production traits measured per doe were total number born (**TNB**), total number born alive (**TNBA**), total number weaned (**TNW**), number of litters produced by the doe (**NL**) and length of lifetime production (**LT**). The mean performances of lifetime production traits per doe were 39.2, 42.0 and 31.2 bunnies for **TNBA**, **TNB** and **TNW**, respectively. **LT** was 8.1 month and **NL** was 4.8 litters. Litter size in which the doe was born constituted a highly significant ($P<0.001$) source of variation in **TNBA**, **TNB** and **TNW**. The heritabilities (h^2) for these traits were low and ranged from 0.05 to 0.13. Heritabilities estimated were reliable and precised since standard errors for heritabilities were low and ranged from 0.003 to 0.076.

INTRODUCTION

Lifetime production of the doe is a function of the length of its productive life and it is an indicator to the doe fertility and prolificacy. Although greater longevity increases generation interval, and hence potentially reduces animal genetic gain, it allows producers to be more selective in choosing replacement does because many does have to be chosen each year. Productivity of the doe rabbit reveals her production during her stay in the herd. Although many experiments have been carried out to compare performance of productive traits (output) of different breeds and crosses, few studies on the evaluation of the lifetime production of doe rabbit were available (RINALDO and BOLET, 1988; SZENDRO *et al*., 1996). This is due to the difficulty to obtain records on this trait as well as the lifetime recording requires also consecutive years contributing to the productive traits of the doe. Although multi-trait mixed-model analyses under a half-sib model has received some attention in some traits in rabbits in recent years, the application of this multi-trait model for lifetime production traits has not been attempted so far. The methods of **REML** or **DFREML** (in estimation of variance components) and **BLUP** (in evaluation of individuals) are nowadays utilized.

The objectives of the present study were: (1) to quantify the non-genetic factors affecting lifetime production traits of New Zealand White rabbits raised in high intensive system of production and (2) to estimate genetic and phenotypic variances and heritabilities for these traits using a sire model.

MATERIAL AND METHODS

Animals and management

Data on New Zealand White rabbits **(NZW)** were collected at ZIKA Nucleus Breeding Farm (Schweizerhof Untergroningen) in Germany over 14 consecutive years of intensive production started from 1982. The females were inseminated firstly at a mean age of 121 days (about 4 months) whereas the mean age at kindling was 153 days (about 5 month). The breeding schedule in this rabbitry was allowed to get a maximum number of 10 litters per doe. The does were inseminated artificially within the first few days after kindling. All inseminations were made at random with a restriction of avoiding close relative matings. Does were palpated 18 days post insemination to detect pregnancy. Those, which failed to conceive, were re-inseminated at the next insemination date, which was repeated every 33 days for the same doe group. Does which were not pregnant three times consecutively were eliminated. On the 28th day of gestation, pregnant does were supplied with a thin layer of sanitised wood shaving to provide a comfortable and warm nest for the bunnies. Litters were weaned mostly at the age of about 28 days. At weaning, each weaned bunny was removed from the doe’s cage and it was individually ear-tagged. After weaning, the growing rabbits were raised in collective cages in another building (8 per cage). All the flock was kept under the same managerial and environmental conditions. Young does were added to the herd as needed to replace those lost by death or by culling.

Housing and feeding

Rabbits were housed in windowed environmentally controlled rabbitry. In the rabbitry, a minimum temperature of 14° C was maintained during the winter (optimum 18° C). The relative humidity was 60% ± 10%. Fresh air circulated in the house using exhaust fans. The breeding animals were kept individually in flat-deck level cages made from galvanised wire. Each cage measured 40 cm width x 60 cm length x 38 cm height and was suspended 1.2 m above the floor level. Each cage was equipped with a feeder, water supply of nipple drinkers and floor plastic plate to protect rabbits against sore hocks. Fibre nesting boxes (38 × 38 × 38 cm) were attached to the cages of the does and they were fixed outside the cages.

Breeding animals fed formulated pelted ration, in which the minimum rate of crude protein was 16% and the maximum rate of crude fibre was 14%. Mineral and vitamin mixtures were given as supplement in the ration. The animals fed *ad libitum* until 16 weeks of age and thereafter they received a restricted quantity of ration (120 - 130 g per day) until the first mating. The clean fresh water was available to the rabbits all the time. The occurrence of diseases was largely avoided by a high standard of hygiene and careful management, so that the rabbits had never been treated with any kind of medication.

Data structure and traits of lifetime production

A total of 14210 litters produced by 2945 does mothered by 1613 dams and fathered by 842 sires were analysed. The lifetime production traits measured per doe during her productive life (in all litters produced by the doe) were: total number born (**TNB**), total number born alive (**TNBA**), total number weaned (**TNW**), number of litters produced by the doe (**NL**) and length of lifetime production *i.e.* length of productive life (**LT**). In this study, does with at least 4 parities were used. Lifetime production for the doe was calculated by summing all records of the doe for each of the five traits (**TNBA**, **TNB**, **TNW**, **NL** and **LT**), after making appropriate adjustments. The total number of bunnies weaned was 88824.

Estimation of variance components

A sire model was used to estimate variance components for pre-corrected lifetime production traits of the doe (data corrected for the effects of year-season of kindling and parity; HARVEY, 1990) using **REML** procedure (**SAS** procedure guide, 1996). The sire model in matrix notation was:

$$Y = X\,b + Z_s\,U_s + e$$

Where: Y= n × 1 vector of pre-corrected lifetime production trait, n = number of records; b = p×1 vector of fixed effects of year - season of birth of doe and litter size in which the doe was born, p = number of levels for fixed effects; U_s= q×1 vector of random effect of sire of doe, q = number of levels for random sire-of-doe effects; X= Design incidence matrix of order n × p, which relates records to fixed effects; Z_s=Design incidence matrix of order n × q, which relates records to random sire effects; **e**= n × 1 vector of random error. For the sire model applied to data of the present work, permanent environmental effects were not included in the model of analysis. Since parity in which the doe was born is not available in data and permanent environment is a combination of dam × parity × litter size in which the doe was born, therefore, this effect was not included in the model. Variance components estimated by **REML** procedure were used for estimating heritabilities (**h^2**) for lifetime production traits as: **$h^2 = 4\,s^2_S/(s^2_S + s^2_e)$**, where **$s^2_S$** and **$s^2_e$** were variances due to effects of sire and remainder, respectively. Approximate standard errors for heritabilities were calculated by the formula described by BECKER (1984).

RESULTS AND DISCUSSION

Means and variations

Means, standard deviations (**SD**) and coefficients of phenotypic variation (**CV**) of different traits of lifetime production are given in Table 1. The means are lower than those estimated by RINALDO and BOLET (1988) who reported that the length of productive life was 508 days (about 17 months) and 581 days (about 19 months) for selected and unselected lines in New Zealand White rabbits, respectively. The same authors added that the total number weaned per doe was 60 and 65 young for the two lines, respectively, while the respective numbers of litters per doe (**NL**) were 10.3 and 11.4 for the two lines. The short productive life in the present study may be due to the fact that system of production practiced in this rabbitry was intensive and the insemination process was done within few days after parturition in addition to that does which were not pregnant three times consecutively were culled.

Table 1: Actual means, standard deviations (SD), coefficients of phenotypic variation (CV) and determination (R^2) for lifetime production traits in New Zealand White rabbits

Trait	Symbol	Mean	SD	CV
Total number born	**TNB**	42.0	18.3	0.413
Total number born alive	**TNBA**	39.2	17.1	0.433
Total number weaned	**TNW**	31.2	14.1	0.430
Length of lifetime production (month)	**LT**	8.1	2.7	0.315
Number of litters produced by the doe	**NL**	4.8	1.8	0.372

No. of does = 2945 No. of records = 14210

Estimates of coefficient of variation (**CV**) for lifetime production traits are relatively high (Table 1). These estimates ranged from 0.315 for **LT** to 0.433 for **TNBA**. The estimates of

CV for litter-size traits of lifetime production (*i.e.* **TNB, TNBA** and **TNW**) were higher than those estimates for **LT** and **NL**.

Non-genetic aspects

Year-season of birth of the doe in this study had non-significant effect on all lifetime production traits studied. Least-squares means for lifetime production traits in different sub-classes of litter size in which the doe was born are presented in Table 2. Litter size in which the doe was born affected (P<0.001) litter-size traits of lifetime production (*i.e.* **TNB , TNBA** and **TNW**). Similarly, SZENDRO *et al.* (1989) reported a significant effect of litter size in which the doe was born on **TNB**. Opposite to litter-size traits of lifetime production, **LT** and **NL** were not significantly affected by litter size in which the doe was born (Table 2).

Table 2. Least-squares means and their standard errors (SE) for the effect of litter size in which the doe was born (LSBD) on lifetime production traits+ in New Zealand White rabbits

LSBD Sub-class	No.	TNB Mean ± SE	TNBA Mean ±SE	TNW Mean ±SE	NL Mean ±SE	LT Mean ±SE
2	135	33.0 ± 2.1	30.3 ± 2.0	24.5 ± 1.6	4.6 ± 0.2	7.7 ± 0.3
3	140	35.8 ± 2.0	33.0 ± 1.9	27.3 ± 1.5	4.8 ± 0.2	7.9 ± 0.3
4	143	36.2 ±.2.0	33.1 ±.2.0	27.4 ±.1.6	4.8 ±.0.2	8.1 ±.0.3
5	149	38.7 ± 1.9	35.6 ± 1.9	29.9 ± 1.5	4.9 ± 0.2	8.3 ± 0.3
6	227	38.4 ± 1.7	35.3 ± 1.7	29.7 ± 1.3	4.8 ± 0.2	7.9 ± 0.3
7	238	40.4 ± 1.7	37.3 ± 1.6	30.9 ± 1.3	4.9 ± 0.2	8.1 ± 0.2
8	292	43.7± 1.6	39.3 ± 1.6	33.3 ± 1.1	5.0 ± 0.2	8.2 ± 0.2
9	378	43.1 ± 1.5	40.2 ± 1.4	31.5 ± 1.1	4.9 ± 0.2	8.3 ± 0.2
10	386	43.3 ± 1.5	39.9 ± 1.4	34.6 ± 1.2	4.7 ± 0.2	8.1 ± 0.2
11	321	46.8 ± 1.5	44.3 ± 1.5	33.4 ± 1.3	4.9 ± 0.2	8.3 ± 0.2
12	234	46.7 ± 1.7	43.5 ± 1.7	33.4 ± 1.3	4.7 ± 0.2	7.9 ± 0.3
13	163	50.0 ± 1.9	46.9 ± 1.9	34.7 ± 1.5	5.0 ± 0.2	8.1 ± 0.3
14	139	49.1 ± 2.0	45.5 ± 2.0	32.8 ± 1.6	4.6 ± 0.2	8.0 ± 0.3
Significance		***	***	***	ns	ns

+ Traits as defined in Table 1. ns = Non-significant, ***= P < 0.001

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The highest means in **TNB**, **TNBA** and **TNW** were observed for does born in large-sized litters ($\geq$ 7 young) relative to does which were born in small-sized litters (Table 2). In agreement with the present results, SZENDRO *et al.* (1989) stated that does originating from large litters also performed well later. In disagreement with the present results, BABILE and MATHERON (1980) and BLASCO *et al.* (1982) reported that does originating from large litters showed lower performance than that of females born in smaller litters. However, the biological model described by BLASCO *et al.* (1982) showed that dams from large-sized litter are lighter in weight at first mating and kindling, *i.e.* dams from large litters would have a lower ovulation rate than those from smaller litters, and would produce, on the average, litters whose size would be less than the ones in which the dam was born. Opposite to this trend, dams from small litters would : (1) have heavier weight at first mating, (2) have higher ovulation rate, and (3) produce larger litters in the next kindling. In general, if a dam has large litters, her daughters will have small litters, and her grand-daughters large litters again, assuming that there is a negative correlation between direct and maternal effects and a positive correlation between direct and grand-maternal effects (BLASCO *et al.*, 1982). This would be applicable both to genetic and environmental effects, and would affect not only litter size but also litter weight at birth and weaning. Such results confirm the fact that maternal effects have a negative environmental influence on daughter's litter size (GARCIA *et al.*, 1982). Therefore, selection for increased growth rate or increased mature size of the dam is expected to increase litter size and litter weight at birth.

Random components of variance and heritabilities

Percentages of the sire variance component (**s^2_s**) for lifetime production traits relative to the total phenotypic variance (**$s^2_e + s^2_s$**) were low and ranged from 1.4 to 3.3 % (Table 3), correspndingly heritabilities (**h^2**) ranged from 0.05 to 0.13. These low estimates of **s^2_s** and **h^2** for lifetime production traits may be due to that maternal variation and non-additive effects were large and could mask any sire additive genetic variance. Unfortunately, literature concerning variance components and heritabilities of lifetime production traits in rabbits is scarce. However, estimates of heritabilities for lifetime traits in polytocus animals are usually low (NAGAI *et al.*, 1988). In agreement with the present results, TRIEBLER (1988) with swine reported that **h^2** estimated from the sire model for length of productive life was low (0.10±0.08). NAGAI *et al.* (1988) in mice reported that h^2 estimated from bivariate mixed model analysis under a full-sib model for the number of parturitions and length of reproductive life were very low (0.01 and 0.01, respectively). Using a single-trait analysis based on mixed-model under a full-sib model, the same author found that sire heritabilities for the two traits were 0.02 and 0.24, respectively.

Table 3. Estimates of sire (s^2s) and remainder (s^2e) variances and heritabilities (h^2) for lifetime production traits estimated by REML using the sire model

Trait+	Sire		Remainder		s^2_e/s^2_s	h^2 ±S.E.
	s^2s	V%++	s^2e	V%++		
TNB	4.04	1.4	295.11	98.6	73.0	0.05 ± 0.003
TNBA	4.46	1.6	281.641	98.4	63.1	0.06 ± 0.006
TNW	4.84	2.6	179.00	97.4	37.0	0.10 ± 0.010
LT	0.224	3.3	6.566	96.7	29.3	0.13 ± 0.006
NL	0.062	1.9	3.136	98.1	50.6	0.08 ± 0.076

+Traits as defined in Table 1. ++ V%= Percentages of sire or remainder component of variance relative to the total phenotypic variance

The standard errors for heritabilities estimated by the sire model were small and ranged from 0.003 to 0.076; indicating that estimates of heritability were reliable and precise (Table 3). For rabbitry of the present work, selection or system of culling may be the main causes for reducing the sire component of variance and consequently a reduction in estimates of **h^2**. Also, the data generated a homogenous number of daughters per sire along with sufficient number of sires (842 sires) or dams (1613 dams) which lead to provide connections between cells. But, the unbalanced data of the present work collected from un-designed experiment may lead to a downward bias in estimates of heritability. MCCARTER *et al.* (1987) found that estimates of heritability from designed experiments were higher than those estimates from field data. Therefore, estimates of heritability calculated from controlled experimental populations may not accurately reflect their applications to other uncontrolled populations. In general, low estimates of all heritabilities obtained for lifetime production traits could be attributed to: (1) the small number of daughters per sire (FERRAZ *et al.,* 1992), and (2) the non-randomness in the distribution of daughters within sire groups (KHALIL *et al.,* 1986)

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REFERENCES

BABILE R., MATHERON G. 1980: Utilisation une composante de l'effect maternal sur la productivite numerique. Premiers resultats. Selection et developpment. *Seance semestrielle, Toulouse,* 43 - 50.

BECKER WA. 1984: Manual of quantitative genetics. (Fourth Edition) *Academic Enterprises, Pullmon, W.A., USA.*

BLASCO A., BASELGA M., GARCIA F., DELTORO J. 1982:. Genetic analysis of some productive traits in meat rabbits. II- A genetic study of growth traits. *2nd World Congress on Genetics Applied to Livestock Production, October 1982, Spain.*

FERRAZ J B S., JOHNSON R K., VAN VLECK L D. 1992: Estimation of genetic trends and genetic parameters for reproductive and growth traits of rabbits raised in subtropics with Animal Model. *J. Appl. Rabbit Res.,* **15**: 131-142.

GARCIA F., BASELGA M., BLASCO A., DELTORO, J. 1982: Genetic analysis of some productive traits in meat rabbits. Numeric traits. *2nd World Congress on Genetics Applied to Livestock Production. October 1982, Madrid, Spain***, 7**:557-562.

HARVEY, W R. 1990: User's Guide for **LSMLMW**. Mixed model least square and maximum likelihood computer program. *PC-Version 2, Ohio State University, Columbus, USA (Mimeograph).*

KHALIL M H., OWEN J B., AFIFI E A. 1986: A review of phenotypic and genetic parameters associated with meat production traits in rabbits. *Animal Breeding Abstracts*, **54** : 724-749.

MCCARTER MN., MABRY JW., BETTRAND J K., BENYSHEK L L. 1987: Components of variance and covariance for reproductive traits in swine estimated from Yorkshire field data. *J. Anim. Sci.*, **64**: 1285-1291.

NAGAI J., LIN CY., MCALLISTER A J. 1988: Simultaneous estimation of genetic parameter of lifetime reproductive traits in mice. *Canadian J. Anim. Sci*., **62**: 1291-1295.

RINALDO D., BOLET G. 1988: Effect of selection for litter size at weaning on productive life of female rabbits. *4th World Rabbit Congress, Budapest, April 1988,* **Vol. 2**, 269 - 274.

SAS, 1996: SAS' Procedures Guide. *"Version 6.12th Ed."; SAS Institute Inc., Cary, NC, USA.*

SZENDRO ZS., LANG M., SZABO J. 1989: Reproductive ability of rabbit does in relation to their litter size. *J. Appl. Rabbit Res*., **12** : 22 - 36.

SZENDRO ZS., BIRO-NEMETH E., RADNAI I., MILISITS G., ZIMANYI, A. 1996: Connection between reproductive performance and productive lifetime of rabbit doe. *6th World Rabbit Congress, Toulouse, France, July 1996,* **Vol. 2**:123 - 126.

TRIEBLER G. 1988: Breeding aspects of length of productive life in pigs. *Archiv fur Tierzucht*, **31**: 291-299.