Proceedings 4th World Rabbit Congress, 10-14 October 1988, Budapest Hungary, Vol. 2, 87-95

DESCRIPTION OF A SELECTION EXPERIMENT FOR TOTAL LITTER WEIGHT AT WEANING PER DOE AND PER YEAR IN TWO REX RABBIT STRAINS

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INTRODUCTION

The usual equation for predicting the response from some generations of selection was given by RENDEL and ROBERTSON (1950). With overlapping generations the situation is more complexe. BICHARD et al (1973) have done a theorical investigation to study the consequences of genetic differences between the groups of breeding animals of different ages, and between the means of their progeny. HILL (1974) developped formal methods to describe such situations, in which genetic responses fluctuate in the early stage of a selection programme. ELSEN (1980) gave some interesting properties of this model. One assumes that the same proprotions are selected from all progeny groups with parents of different ages. HOPKINS and JAMES (1977 and 1979) compared genetic responses from selection strategies based on selection among all potential parents of the following year's crop (parent selection) with those based on selection only within progeny crops (progeny selection). Therefore the effects of overlapping generation on the prediction of genetic gain are rather complex. It is difficult to choose the best selection strategie or to study a selection experiment. In many selection experiments, generation do not overlap. Nevertheless most of commercial selection company working with rabbits select strain with overlapping generations. Our first aim is to increase our experience of the management of strains with overlapping generations.

On the other hand to reach a global selection goal, quantitative genetic theory indicate that the best way is to use a selection index which combine various selection criteria. For example if total litter weight at weaning is the selection goal, the selection criteria will be litter size at weaning and mean individual weight at weaning. EISEN (1981) compare different selection procedures for improving total litter weight : "individual" selection for total litter weight, selection within families for total litter weight, indirect selection for either litter size or mean individual weaning weight, and index selection. Conclusion from these studies is that indirect selection by using litter size at birth as a selection criterion and standardized litters may be more effective than direct selection because it avoids the high negative correlation between litter size and individual weaning weight which results during preweaning growth in unstandardized litters. However numerical results of EISEN (1981) emphasize also the need to have accurate estimates of all genetic parameters for purposes of predicting selection responses. In our rabbit strains, this is often not possible. In mice, there was various selection experiments for total litter weight (STEANE and ROBERTS, 1982). Sometimes there is a selection response. Realised genetic correlation between litter size and weaning weight in mice seems to depend on whether or not litters are standardized at birth (EISEN, 1981). There is a positive correlation for standardized litters and a zero correlation in unstandardized litters. In rabbits, negative genetic correlations were estimed from data where litter sizes were not standardized (MASOERO, 1982). We do not find a selection experiment on total litter weight at weaning in rabbits. Our second aim is to do such an experiment. As some other strains were selected on the litter size (MATHERON et POUJARDIEU, 1984) we do not choose the indirect selection strategie described by EISEN (1981). We decide to use a selection criterion as near as possible from the selection goal. We do not use a selection index which combine various selection criteria for it was not possible to estimate genetic correlations. At least, we do not standardize litters at birth for the moment. It could be interesting to do later another selection experiment with standardized litters. However, even with standardized litters, some maternal effects remain.

DEFINITION OF A SELECTION CRITERION

Origin of our Rex Rabbit strains is Mexico. We also use some bucks bought in Europe. Castor and Chinchilla are the color of the skins of the two strains. Performances of these strains were summarized by ROCHAMBEAU and VRILLON (1982). Rabbits were reared in an isolated building, not heated

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and statiscally ventiled. The building has windows ; bucks and does were lighted 16 hours per day. Mating first ocured at 160 days. Each breeding rabbit had an individual wire cage. Broiler rabbits were raised in collective cages in another building. All rabbits were fed with the same commercial pellet. Performance traits collected from does were : number of young rabbits alive and dead at birth, number of young rabbits at weaning, mating date, birth date, weaning date, total litter weight at weaning, number of the sire of each litter.

We will define some variables

P_n : total weaning weight of the nth litter,
JMB_n : birth date of the nth litter,
IMB_n : $JMB_n - JMB_{n-1}$ with $n \geq 1$
NBS_n : litter size at weaning of the nth litter
NSA_n : number of mating for the nth litter.

Doe management utilized an half-intensive breeding schedule. Mating occured 10 days post partum. Diagnostics of pregnancy through abdominal palpation followed 10 days later. Does diagnosed not pregnant were returned to bucks 4 days later. Then theorical interval between parturition is

$$IMB_n = 10 + 14 * (NSA_n - 1) + 31$$

if 31 days is the gestation length.

To estimate the value of one doe for the selection goal (total litter weight at weaning per doe and per year) from one litter we have various litter selection criteria. We study two of them :

$$CMB_n = \frac{P_n * 365}{JMB_n - JMB_{n-1}}$$

and

$$MTH_n = \frac{P_n * 365}{10 + 14 * (NSA_n - 1) + 31}$$

We compare CMB_n and MTH_n with a weight productivity criterium :

$$PPT_n = \frac{P_n * 365}{41}$$

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and with a litter size productivity criterium :

$$PNT_n = \frac{NBS_n * 365}{41}$$

To summarize life time performances of one doe which have done n litters we can choose between two methods :

$$\overline{M1} = \frac{1}{n} \sum_n \frac{P_n * 365}{IMB_n}$$

or $$\overline{M2} = \frac{[\sum_n P_n] * 365}{[\sum_n IMB_n]}$$

Then we have 6 life time selection criteria : $\overline{CMB_1}$, $\overline{CMB_2}$, $\overline{MTH_1}$, $\overline{MTH_2}$, $\overline{PPT}$ and $\overline{PNT}$.

CHOICE OF A SELECTION CRITERION

Statistical parameters of litter selection criteria are presented in table 1. There were computed on a sample of 1330 litters. Greatest weight productivity is given by PPT_n, for the interval between parturitions is minimum. The mean value of MTH_n is greater than the mean value of CMB_n. The difference between the two intervals between parturitions (the first tabulated with the birth dates, the second tabulated with the number of matings) is greater than 0 with a probability of 0,93. The difference is greater than 10 days with a probability of 0,2. At least the difference is greater than 14 days with a probability of 0,06. Phenotypic correlations between criteria are high. MTH_n is more correlated with PPT_n and PNT_n than CMB_n.

Statistical parameters of the lifetime selection criteria are presented in table 2. They were computed on the first three litters of 83 does which have done more than two litters. Results are very similar to those of table 1. Standart deviations are smaller. Then data were analyzed by least-squares procedures through analysis of variance. We used the following mixed model :

$$Y_{ijklm} = \mu + b_i + P_j + M_{jk} + F_{jkl} + E_{ijklm}$$

Y_{ijklm} = observed value of a given variable

μ = overall mean

b_i = fixed effect of parity

P_j = random effect of the j^{th} sire

M_{jk} = random effect of the k^{th} dam mated with the j^{th} sire.

F_{jkl} = random effect of the l^{th} doe from the jk^{th} dam.

E_{ijklm} = random error.

If V_P is the sire component, V_M the dam component, V_F the doe component and V_E the residual component, we have for the coefficient of heritability, h^2

$$h^2 = \frac{4V_P}{V_P + V_M + V_F + V_E}$$

and for the coefficient of repeatability, R^2

$$R^2 = \frac{V_P + V_M + V_F}{V_P + V_M + V_F + V_E}$$

Variance components were estimated with the method III of Henderson.

To study parity effect, we use a mixed model with two effects (a fixed effect : parity, a random effect : sire) on a sample of 1243 litters made by 358 does out of 45 sires. The parity effect have 9 levels. Parity effect was highly significant for MTH and PPT, but not for CMB. Weight productivity goes up till the 4^{th} or the 5^{th} litter (Figure 1). Heritability of the litter criteria is around 0, 11. Heritability of the weight productivity and the litter size productivity is around 0,05. These values are small in relation to the values of the bibliography (BASELGA et al, 1982 ; KHALIL et al, 1986). Heritability of the lifetime criteria are larger. In conclusion, weight productivity is determined first by litter size. Phenotypic correlations between the criteria are high. Heritability of MTH is larger than heritability of CMB. However, these estimations are not very reliable. Is the difference significant ? When one rate the does on MTH or on CMB, lists are very similar. On the other hand a birth date is a more reliable data than a number of matings. Therefore we choose CMB. Differences between CMB_1 and CMB_2 are small. As usual indexation programmes work with CMB_1, we choose CMB_1, (MATHERON and POUJARDIEU, 1984). However, further work is needed on the selection criteria.

SELECTION PROCEDURES

We have 3 lines : a selected line and a control line from the Castor Rex strain, a selected line from the Chinchilla strain. The generations overlapp. In each line we have 2 cohorts bred with an interval of 8 months. When the youngest females have done 2 or 3 litters we ranked does on an index. The index uses data of the doe, of its sisters, and of its mother (MATHERON et POURJARDIEU, 1984). All oldest does and bucks are casted. Bucks and does of the new cohort are chosen between young rabbits of the best ranked does. Eight months later, we will have another cohort. In the selected lines we have 8 reproduction groups of 2 bucks and 7 does. The control line has 4 reproduction groups of 2 bucks and 7 does. Bucks stay in the group of their sires. Does go in another reproduction group.

This selection experiment has begun in August 86. The first cohort was bred at the begining of 87, and the second in autumn of 87. During the experiment we will have 10 cohorts.

ACKNOWLEDGEMENT

Authors thank technical staff of le Magneraud for their contribution.

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Table 1 : Means, standart deviations, heritability (H2), repeatability (R2) and phenotypic correlations between the four litter criteria computed on a sample of 1330 litters. MTH_n, CMB_n and PPT_n are weights of rabbits weaned per doe and per year in kg. PNT_n is a number of rabbits weaned per doe and per year (cf. definition of the selection criteria).

	Mean	Standart deviation	CMB_n	PPT_n	PNT_n	H2	R2
MTH_n	18,9	9,7	0,94	0,92	0,84	0,11	0,14
CMB_n	17,3	9,5	-	0,85	0,77	0,11	0,12
PPT_n	21,5	10,0	-	-	0,91	0,06	0,17
PNT_n	44	1,9	-	-	-	0,04	0,21

Table 2 : Means, standart deviations, heritability (H2) and phenotypic correlations between the six doe criteria computed on the first three litters of 83 does. PNT is a number of rabbits weaned per doe and per year. All the others criteria are weights of rabbits weaned per doe and per year in kg (cf. definition of the selection criteria).

	Mean	Standart deviation	$\overline{MTH}_2$	$\overline{CMB}_1$	$\overline{CMB}_2$	$\overline{PPT}$	$\overline{PNT}$	H2
$\overline{MTH}_1$	21,6	5,8	0,98	0,97	0,92	0,85	0,72	0,34
$\overline{MTH}_2$	21,0	5,9	-	0,96	0,95	0,81	0,71	0,34
$\overline{CMB}_1$	20,3	5,7	-	-	0,97	0,78	0,65	0,18
$\overline{CMB}_2$	19,2	6,0	-	-	-	0,71	0,62	0,26
$\overline{PPT}$	25,2	5,6	-	-	-	-	0,84	0,19
$\overline{PNT}$	49	12	-	-	-	-	-	0,24

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Total weaning weight per doe and per year in kg

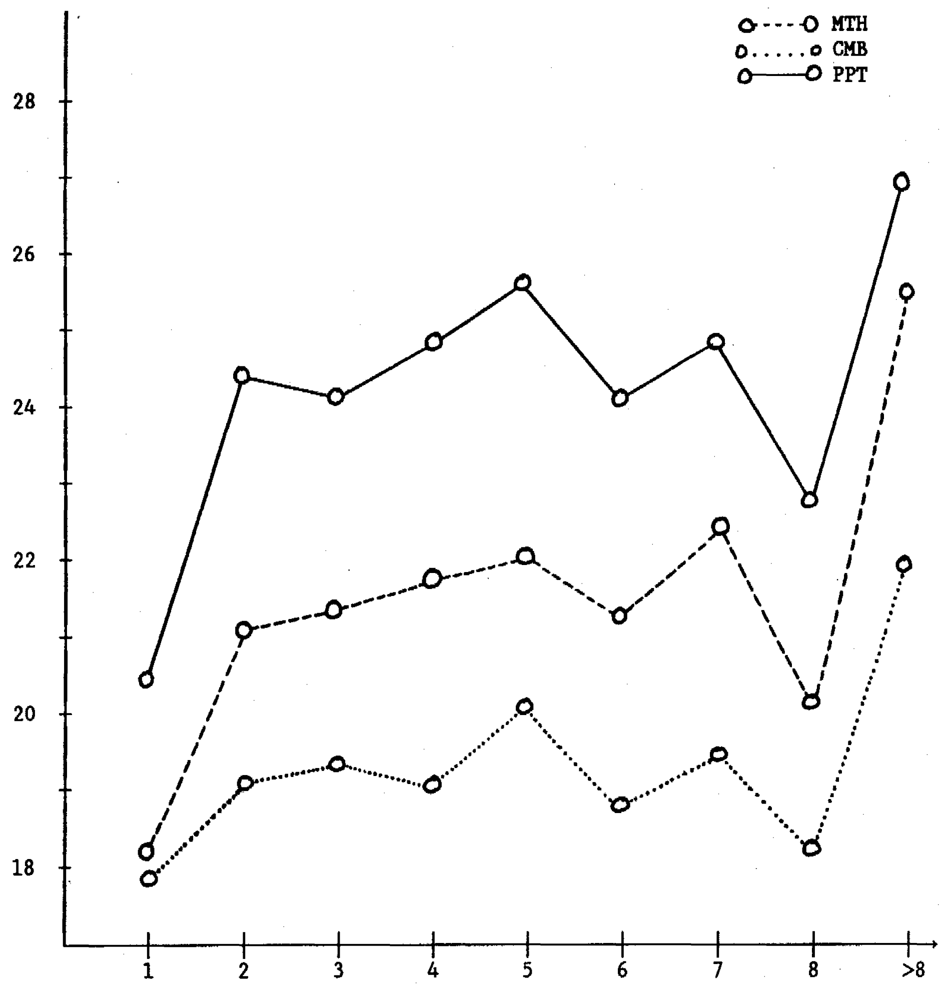

Figure 1 : Parity effect on the 3 litter criteria on a sample of 1243 litters made by 358 does out of 45 sires

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Let P_n be the total weaning weight of the n^{th} litter, JMB_n be the birth date of the n^{th} litter, the selection criterion is, for a doe with n litters :

$$CMB_1 = \frac{1}{n} \sum_{k=1}^{n} \left[P_k * \frac{365}{(JMB_k - JMB_{k-1})}\right]$$

The heritability of CMB_1 is around 0.2. We have 2 selected lines with 16 bucks and 56 does each, and a control line with 8 bucks and 28 does. In each strain, there are 8 or 4 reproduction groups with 2 bucks and 7 does. The sons of the bucks of one reproduction group take the place of this fathers. The daughters of the does of one reproduction group go in the others groups according to their relationship coefficients. In each line, we have 2 cohorts. The oldest cohort is born 8 months before the yongest cohort. Eight months after the birth of one cohort, the does are rated on an index which combine it own data, the data of it mother, the data of its full sisters and half sisters. The oldest cohort is casted. The new cohort is made by the daughters of the better rated does. We had the first litters of the first cohort in autumn of 86. During the selection experiment we will have 10 cohorts.

PROTOCOLE D'UNE EXPERIENCE DE SELECTION SUR LE POIDS DE LAPEREAUX SEVRES PAR FEMELLE ET PAR ANNEE DANS DEUX SOUCHES DE LAPIN REX

Si P_n est le poids total de la portée (n) au sevrage, JMB_n la date de naissance de la portée (n), le critère de sélection retenu s'écrit pour une femelle qui a fait (n) portées :

$$CMB_1 = \frac{1}{n} \sum_{k=1}^{n} \left[P_k * \frac{365}{(JMB_k - JMB_{k-1})}\right]$$

L'héritabilité de ce critère serait voisine de 0,2. L'expérience de sélection comprend 2 souches sélectionnées de 16 mâles et 56 femelles chacune, ainsi qu'une souche témoin de 8 mâles et 28 femelles. Les souches sélectionnées sont divisées en 8 groupes de reproduction de 2 mâles et 7 femelles. La souche témoin comprend 4 groupes de 2 mâles et 7 femelles. Les mâles d'un groupe sont remplacés par leurs fils. Les filles des femelles d'un groupe sont réparties dans les autres groupes en fonction des coefficients de parenté. Une souche se compose de deux cohortes de reproducteurs nées à 8 mois d'écart. Tous les 8 mois l'ensemble des femelles est indexé d'après le critère ci-dessus en combinant ses propres performances, celles de sa mère, de ses propres soeurs et de ses demi-soeurs. La cohorte des vieux reproducteurs est éliminée. Il sont remplacés par des descendants des femelles les mieux classées. La cohorte initiale a commencé à produire à l'automne 1986. Il est prévu de faire produire 10 cohortes.

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