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ESTIMATION OF GENETIC PARAMETERS AND TRENDS FOR BIRTH WEIGHT CRITERIA IN HYCOLE D LINE

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ABSTRACT

This study aims to estimate the genetic variability of different rabbit weight criteria at birth in the Hycole D line. There were 2108 litters measured in the data set, realized from December 2009 to September 2010. Heritabilities estimated for birth weight mean, total litter birth weight, minimal birth weight, maximal birth weight, range between maximal and minimal birth weight and total born alive rabbits were 0.15, 0.13, 0.07, 0.12, 0.11 and 0.10, respectively. Genetic correlations of the minimal birth weight with the other birth weights and within-litter variation of birth weight were favourable. The genetic variability of minimal birth weight and favourable genetic correlations with other criteria allow an efficient selection of this criterion in a breeding scheme. This criterion was added to the breeding objective in September 2010. A second data set consists of 7219 measurements recorded from December 2009 to January 2012 was used to estimate the genetic progress achieved. The gain on the criterion weight of the lightest rabbit is +0.9 g for animals born in 2011 compared to those born in 2010.

Key words: Rabbits, genetic parameters, genetic trends, birth weight, litter traits.

INTRODUCTION

The continual increase in litter sizes, related to the selection on prolificacy, has reduced the individual weight of the young at birth (Bolet, 1998). Several studies have demonstrated that the reduction of the rabbit weight at birth has an impact on young rabbit survival during lactation and fattening (Poigner *et al.*, 2000) and on young growth (Perrier, 2003). Bolet (1998) also highlighted the impact of within-litter heterogeneity of birth weight on the survival of the young rabbit. This trend was also widely observed in selected lines of pigs (Quiniou *et al.*, 2002). An experiment conducted at the INRA (Garreau *et al*, 2008) and a study carried out in Hycole (Dubois, 2007) demonstrated the possibility to improve, by selection, the individual weight and within-litter homogeneity of weight at birth by performing an individual weighing of the young rabbit. The study of Dubois (2007) also showed that the individual weighing of young rabbits at birth represents a substantial workload (3 min / litter measured).

Our study aims to define one or more heritable criteria to improve weight and homogeneity of weight of young rabbits at birth, while limiting the number of measures to achieve. The second part of the study will present the progress achieved with the selection on the weight of the lightest rabbit.

MATERIALS AND METHODS

Data

The measures have been carried out between December 2009 and September 2010 at the Hycole station on females of the maternal line D. This line is managed with a reproductive cycle of 42 days. These females were measured on their three first kindlings. Due to the organization of the farm, the animals were inseminated on two days: Thursday (48.2% of litters) and Friday (51.8%). For practical reasons, the weighing was done at a fixed date on Tuesday afternoon whatever the day of parturition (Sunday to Tuesday). Litters were not modified between parturition and control, only the dead kits have been removed. The day of parturition of females was recorded in order to differentiate the length of gestation to the length of extra uterine life at the time of weighing. The number of young rabbits born alive (BA) was observed at birth. During measurement, the various traits measured on each litter were: total weight of the litter (TW), weight of the lightest rabbit (MIN), weight of the heaviest rabbit (MAX), number of rabbits weighed (N). The heaviest and lightest rabbits were chosen visually. Litters with less than 2 rabbits present the day of measurement were excluded from the analyse. From these measurements, the range of weight between the lightest rabbit and heaviest rabbit (Range) and the average weight of each litter (AW) were calculated. Litters with more than 18 rabbits at the measurement were discarded from the analyse (6 litters). The sample analyzed to estimate genetic parameters consisted of 2108 litters measured. The pedigree file includes all males and females born between 2001 and 2010, 52968 animals. The criterion MIN has been incorporated into the multi-traits breeding objective of the line D since September 2010. The weight applied to this criterion represents 35% of the phenotypic standard deviation of the selection index. Between September 2010 and February 2012, 7,219 litters were measured on the criterion MIN. The pedigree file to estimate the genetic trend included all males and females born between 2001 and February 2012, 53205 animals.

Methods

Correlation and regression coefficients between the number of rabbits weighed and MIN, MAX and Range were estimated by linear regression in EXCEL. Significance of fixed effects was tested by multiple analyze of variance using the ASReml software (Gilmour *et al.*, 2009). The random effect of permanent environment of the female was included into the model to take into account the repetition of performances for each female. The fixed effects retained for the analyses are: week of parturition (week*year), the combined effect of the class of gestation (1, 2 or 3) and the physiological status during gestation (lactating or not lactating), the type of semen used (homospermic or heterospermic AI), the length of gestation and the number of days of extra uterine life before weighing. These two last effects were taken into account because artificial inseminations were performed on two different days. The number of rabbits weighed was also added as a covariate for all traits expect for TW. The model to evaluate the criterion BA only included the effect of week of parturition and the combined effect of the class of gestation and the physiological status during gestation. All the effects included for the various traits are significant ($p < 0.001$) except for the effect of the length of gestation on TW ($p=0.05$) and on Range ($p=0.05$) and the effect of the male used on Range ($p=0.08$). Genetic parameters (variance and covariance components) were estimated with the restricted maximum likelihood method (REML) applied to an animal model by using the software ASReml. In addition to the fixed effects and covariate, two factors with random effects were included into the model: the genetic additive effect of the female and the permanent environment effect for each female. Traits were analyzed individually at first and then in pairs in order to estimate genetic correlations. Simultaneous evaluation of all the traits could not be done for computational reasons. Breeding values of animals for the criterion MIN were estimated on all animals of the second data set by BLUP method (Best Linear Unbiased Predictor) applied to an animal model using the software ASReml (Gilmour *et al.*, 2009). The model used is the same than the one used for the estimation of genetic parameters. The annual genetic progress was estimated by averaging the breeding values of animals by year of birth.

RESULTS AND DISCUSSION

Effect of the number of rabbits weighed

The increase in the number of rabbits per litter caused a decrease of the average weight of young rabbits (Figure 1). The decrease of the individual weight as a consequence of the increase of number of rabbits per litter has already been demonstrated by Poigner *et al.* (2000). The weight of the heaviest (MAX) is moderately influenced by the number of rabbits weighed. An additional rabbit in the litter will decrease the weight of the heaviest of 0.5 g (regression coefficient, r=0.71). However, the weight of the lightest (MIN) decreases continuously with the increasing number of rabbits. An additional rabbit will decrease the weight of the lightest rabbit of 2.5g (r=0.97). The range of weight is strongly influenced by the number of rabbits per litter. There is a linear relationship between the number of rabbits weighed and the range of weight (r=0.987). An additional rabbit per litter causes an increase of 1.99 g of the range of weight. Dubois (2007) highlighted a strong correlation between the phenotypic standard deviation of within-litter weight at birth and range of weight between the heaviest rabbit and the lightest rabbit of each litter (0.91). The increase in the range of weight showed a deterioration of the homogeneity of within-litter weight related to the increase in the number of rabbits per litter.

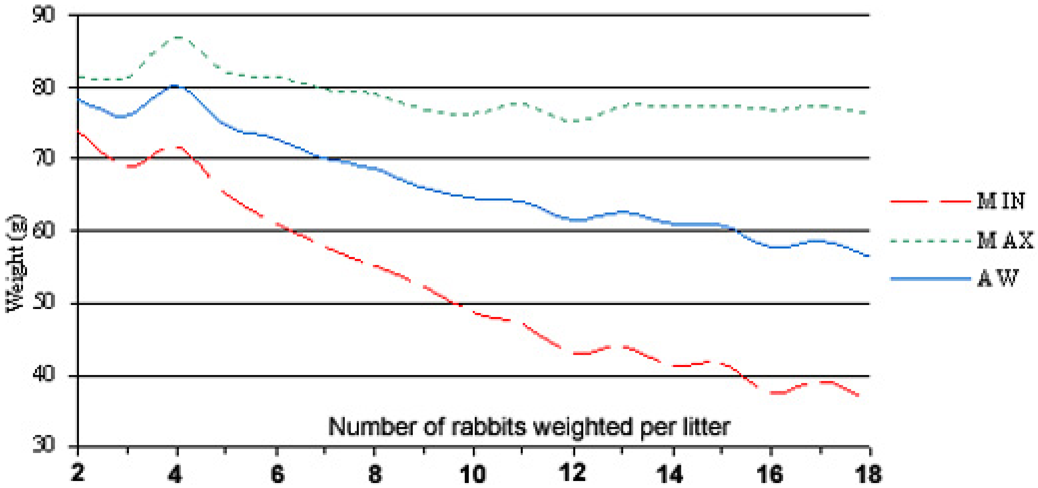

Figure 1: Evolutions of the average weight of young rabbits (AW), weight of the lightest rabbit (MIN) and weight of the heaviest rabbit (MAX) depending on number of rabbits weighed per litter.

Genetic parameters

The heritability values ranged between 0.08 and 0.14 (Table 1). Estimated heritabilities are consistent with those obtained in the literature. For the average weight, heritability estimated by Dubois (2007) equal to 0.20, this value is in the same order of magnitude as in our sample (0.14). Whereas Canario *et al.* (2010) reported a much higher value (0.32) for piglets. Garreau *et al.* (2008) estimated a heritability of 0.06 and a repeatability of 0.06 for the individual weight of the rabbit at birth. The criterion MIN had a lower heritability (0.08) than other weight criteria (0.11 to 0.14). Wolf *et al.* (2008) estimated a heritability of 0.10 for the weight of the lightest piglet at birth. For the range of weight (R), the heritability is 0.11 against 0.02 in the study of Wolf *et al.* (2008). In other studies, the homogeneity of within-litter birth weight was estimated with the standard deviation of within-litter birth weight with heritabilities ranging from 0.10 in the rabbit (Dubois, 2007) and 0.14 in piglets (Canario *et al.*, 2010).

Table 1: Genetic parameters of average birth weight (AW), total weight of the litter at birth (TW), birth weight of the lightest rabbit (MIN), birth weight of the heaviest rabbit (MAX), range of weight between the lightest rabbit and heaviest rabbit (Range) and the number of born alive (BA).

	Line D Hycole	
	h^2	c^2
AW	0.14 (±0.05)	0.19 (±0.05)
TW	0.12 (±0.05)	0.08 (±0.05)
MIN	0.08 (±0.04)	0.11 (±0.04)
MAX	0.13 (±0.04)	0.13 (+0.05)
Range	0.11 (±0.03)	0.01 (±0.01)
BA	0.10 (±0.04)	0.10 (±0.05)

h^2: heritability (± standard error), c^2: effect of permanent environment (± standard error).

In the study of Garreau *et al*. (2008), homogeneity of the birth weight was analyzed by modelling the residual variance of weight according to the method of SanCristobal-Gaudy *et al.* (1998). The authors explain the very low heritability of the trait (0.012) by the change of scale related to the transformation of values for the analysis of heterogeneous variances. The heritability of number of born alive (BA, 0.10) is in agreement with the values estimated by Piles *et al.* (2006) between 0.07 and 0.122. The repeatability of the traits ranged between 0.12 (Range) and 0.33 (AW). These heritability values indicate that there is significant genetic variability for the criteria of birth weight: AW, TW, MIN, MAX, Range and for the number of born alive. These traits also have a phenotypic variability with a coefficient of variation between 0.15 and 0.30 depending on criterion. It is possible to improve these traits by selection in the Hycole D line.

Genetic correlations between the various criteria are shown in Table 2. The weight of the lightest rabbit (MIN) is strongly correlated with AW (0.83) and TW (0.77). The same trend is observed between the weight of the heaviest rabbit (MAX) and the criteria AW (0.96) and TW (0.94). The criteria of litter weight are strongly correlated. Range is moderately correlated with AW, TW and MAX. Canario *et al*. (2010) also showed for piglets a positive genetic correlation (0.36) between the standard deviation of within-litter weight and average litter weight.

Table 2: Genetic correlations between average birth weight (AW) total weight of the litter at birth (TW), birth weight of the lightest rabbit (MIN), birth weight of the heaviest rabbit (MAX), range of weight between the lightest rabbit and heaviest rabbit (Range)and the number of born alive (BA) (± standard error).

	TW	MIN	MAX	Range	BA
AW	0.07 (±0.25)	0.83 (±0.09)	0.96 (±0.04)	0.40 (±ND)	-0.05 (±0.28)
TW		0.77 (±0.14)	0.94 (±0.05)	0.58 (±0.20)	0.75 (±0.12)
MIN			0.44 (±0.25)	-0.39 (±0.24)	-0.22 (±0.31)
MAX				0.64 (±0.18)	0.22 (±0.18)
Range					0.33 (±0.26)

ND: not determined value (convergence problem).

However, there is a negative but favourable correlation between MIN and Range (-0.39): improvement of the weight of the lightest rabbit tends to reduce the range of within-litter weight. The positive phenotypic and genetic correlation observed in pigs (Damgaard *et al.*, 2003 and Wolf *et al*., 2008) between the improvement of the weight of the lightest piglet and the reduction in mortality at birth and lactation confirms the choice of this criterion. Moreover, Wolf *et al*. (2008) estimated a favourable genetic correlation between the weight of lightest piglet with the number of stillborn (-0.5) and with losses from birth to weaning (-0.36). According to this last study, range of weight has a negative genetic correlation with the different criteria of mortality (from 0.24 to 0.55). The standard errors for genetic correlation between the number of born alive (BA) and the criteria AW and MIN (-0.05 (±0.28) and -0.22 (±0.31) respictively) are too large to interpret whether these correlations are favorable or not. However, the relationship between BA and TW is strong and positive (0.75) and is consistent with the trend observed by Bolet (1998). Prolificacy is positively correlated with the criterion MAX (0.22). The range of weight is negatively correlated with the litter size (0.33), suggesting that an increase in the number of born alive tends to increase the rage of weight and therefore the heterogeneity. These trends must be analyzed with caution due to the low precision of some estimates (standard deviations of estimation error greater than 0.20). However, correlations generally unfavourable between birth weight criteria and prolificacy highlighted in our study are consistent with results of the literature for rabbits or piglets.

Genetic trends

Data collected between 2009 and 2012 are used to estimate the genetic progress realized on the criterion MIN since its introduction in the breeding objective in September 2010. Selection on the criterion MIN allowed a genetic gain of 0.4 g of weight for the lightest rabbit for animals born in 2010 compared to those born in 2009. From 2010 to 2011, the genetic gain was 0.9g. The objective of genetic progress when introducing the criterion was 1 g per year from 2011. This first result confirms the possibility of improving the weight of the lightest rabbit by selection. The heritability of MIN with the second data set is 0.11 (± 0.02).

CONCLUSIONS

This study has highlighted the possibility of direct selection on several criteria of weight measured on the litter at birth.. Genetic correlations highlight a negative relationship between the number of rabbits per litter and homogeneity (Range) as well as some criteria of weight (AW and MIN). The criterion MIN is positively correlated with Range as well as other weight criteria. A selection of MIN would both improve the average weight of young rabbits at birth, while reducing the range of weight of the litter. In addition, the measure of weight of the lightest rabbit offers the advantage of performing a single measurement per litter. Weighing the rabbit on a fixed day probably causes a bias in the measurement of the trait, but a weighing after birth is incompatible with production constraints. This bias is mitigated by the introduction of the effects of gestation duration and number of days of extra-uterine life. The introduction of the criterion MIN into the breeding objective showed a significant genetic evolution after 18 months. It will be important to study subsequently the impact of this evolution on other criteria including the within-litter heterogeneity and viability of animals.

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