

RELATIONSHIPS BETWEEN OVULATION RATE AND EMBRYONIC SURVIVAL IN
VARIOUS STRAINS OF RABBITS

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INTRODUCTION

In polytocous mammals like rabbits, litter size at birth depends on number of ova shed and embryonic viability. Selection on litter size may act on these two components and its efficiency is determined by the pattern of the relationship between each other (MATHERON et MAULEON, 1979). The purpose of the present investigation was to study the variability of this relationship in dam strains of rabbit, selected on litter size at the INRA (France).

MATERIALS AND METHODS

1. Animals

Four dam strains have been used :

- A1077 : Deriving from the New-Zealand White breed, this strain was selected on litter size at weaning since 1976, according to a method optimized by MATHERON and ROUVIER (1977).
- A9077 : Same origin as the A1077, but unselected.
- A1066 : Issuing from the Californian breed and selected for litter size at birth according to the same method as the A1077.
- Hyperfertile strain : Synthetic strain, developed from hyperfertile breeding does detected in farms with a performance recording system (de ROCHAMBEAU, 1985). Later on in the text, it will be called "Hyper".

In one experiment, the Fauve de Bourgogne was used as a common tester.

In all these experiments, females were slaughtered between 12 and 16 days after mating. The number of ova shed (NO) was estimated by counting the corpora lutea on both ovaries. The genital tract was dissected to count the number of implantation sites (NI) and of live embryos (NS), the criteria being the embryo irrigation and the presence of heart-beats.

2. Origin of data

The data analysed resulted from four experiments (Table 1).

TABLE 1 : Origin of data

Experiment	Year	Number of pregnant does	Dam Strain	Sire Strain	Embryo type (purebred or crossbred)	Parity	Reference
1	74-75	35	A1077 A1066	Fauve de Bourgogne	crossbred	2	HULOT-MATHERON 1979
2	77-78	95	A1077 A1066	A1077 A1066	purebred	1 2 4	HULOT-MATHERON 1981
3	87	107	A1077 A1066 A9077	A1077 A1066 A9077	purebred and crossbred	4	unpublished
Hyper fertiles	86	123	A1077 Hyperf.	A1077 Hyperf.	purebred	1	unpublished

3. Statistical methods

We analysed the relationships of the number of ova shed (NO) with :

- NI : number of implantation sites
- NS : number of live embryos
- IR : $100 \times NI/NO$: implantation rate
- SR : $100 \times NS/NO$: survival rate
- SRA : $100 \times NS/NI$: survival rate after implantation
- ND : $NO-NS$: number of dead embryos at slaughter
- NDB : $NO-NI$: number of embryos dying before implantation
- NDA : $NI-NS$: number of embryos dying after implantation.

At first, we analysed these 9 variables with the following model (1) of analysis of variance :

(1) $Y_{ijklm} = \mu + S_i + P_j + T_k + E_l + e_{ijklm}$ where :

S_i was the fixed effect of the dam strain (4 levels)

P_j was the fixed effect of the parity (3 levels : 1, 2 and 4)

Tk was the fixed effect of the embryo type (purebred or crossbred)

El was the effect of the experiment (4 levels).

Then, analysis of covariance were performed for NI, NS, IR, IS, with NO as covariate. Linear (2) and quadratic (3) models were successively tested :

$$(2) Y_{ijklm} = \mu + S_i + P_j + T_k + E_l + \beta_i X_{ijklm} + e_{ijklm}$$

$$(3) Y_{ijklm} = \mu + S_i + P_j + T_k + E_l + \beta_i X_{ijklm} + \beta'_i X^2_{ijklm} + e_{ijklm}$$

For the coefficients of covariates, the statistical significance of its global value and of the between-strain heterogeneity has been tested. Coefficients have been calculated as a whole and by strain.

RESULTS

Table 2 reports the distribution, according to genotype and parity, of the 360 pregnant does (i.e. having at least one implantation site).

TABLE 2 : Number of does by strain, parity and embryo type
P : Purebred C : Crossbred

Embryo type		Strain							
		A1077		A1066		A9077		Hyper	
		P	C	P	C	P	C	P	C
Parity	1	30	23	18	-	-	-	90	-
	2	17	20	12	15	-	-	-	-
	4	34	10	29	18	23	21	-	-
Whole		81	53	59	33	23	21	90	-

1. Analysis of variance - Model 1 (Table 3)

There was a highly significant effect of dam strain on number of ova shed and on pre-implantation losses. The A1066 does shed more ova and suffered greater losses than the 3 others, which did not differ significantly. No significant effect of doe strain was found on number and percentage of live embryos at any stage. The embryo type exhibited no more than a slightly significant effect on survival rate after implantation, the crossbred being more viable. Parity displayed a significant effect on most variables : NO increased while IR, SR and SRA decreased ; consequently, parity did not show any significant effect on NI or NS.

TABLE 3 : Results of the analysis of variance. significance of effects and least-square estimates
 NS : not significant ; significant : + P<0.10 ; * P<0.05 ; ** P<0.01

	Number of			Number of embryos dying			Implantation rate IR	Survival rate at D14 SR	Survival rate after implantation SRA
	ova shed NO	implantation sites NI	Live embryos NS	Whole ND	Before implantation NDB	After implantation NDA			
Doe strain	**	NS	NS	*	**	NS	NS	NS	NS
A1077	11.4a	9.7	8.8	2.6a	1.7a	0.9	85.2	77.4	89.6
A1066	13.1b	10.4	9.3	3.8bc	2.7bc	1.1	80.4	72.8	90.6
A9077	10.4a	9.2	7.9	2.5a	1.2a	1.2	87.6	76.6	86.7
Hyper	10.9a	9.3	8.6	2.3ac	1.6ac	0.7	84.5	78.1	92.0
Parity	**	NS	NS	**	**	*	*	**	*
- 1	9.9a	9.1	8.5	1.4a	0.8a	0.6a	90.1a	83.6a	93.9a
- 2	11.6b	10.0	9.2	2.4a	1.5a	0.9ab	86.7ab	79.6a	90.9ab
- 4	12.8b	9.7	8.3	4.5b	3.1b	1.4b	76.5b	65.5b	84.4b
Embryo type	NS	NS	NS	NS	NS	+	NS	NS	+
- Purebred	11.4	9.5	8.3	3.1	1.9	1.2	83.5	73.6	87.4
- Crossbred	11.5	9.8	9.0	2.5	1.7	0.8	85.3	78.8	92.1
Experiment	**	+	+	+	NS	NS	NS	NS	NS
σ^2_E	6.15	9.37	10.01	7.58	5.63	1.76	405.52	528.54	237.98

2. Analysis of covariance (Table 4)

TABLE 4 : Analysis of covariance. Statistical significance of linear and quadratic adjustments, value of global and within-strain coefficients. Not significant : NS ; Significant : + P<0.05 , * P<0.05 , ** P<0.01 ; LC : Linear coefficient ; QC : quadratic coefficient.

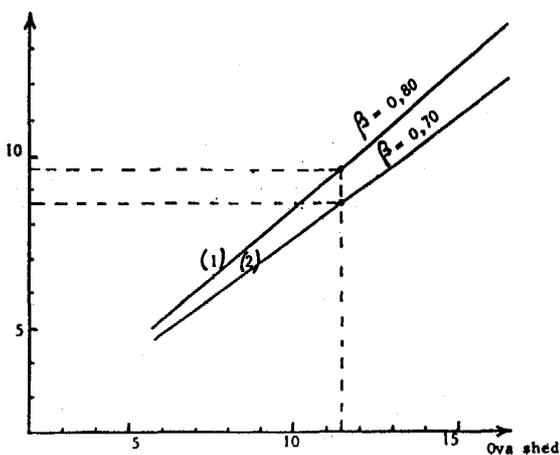
	NI		NS		IR		SR	
Linear regression								
Total	0.80 **		0.70 **		0.15 NS		- 0.09 NS	
between strain heterogeneity	NS		NS		NS		NS	
Quadratic regression								
	LC	QC	LC	QC	LC	QC	LC	QC
Total	1.1x **	-0.01x ² NS	1.1x **	-0.01x ² NS	3.7x +	-0.14x ² +	3.4x NS	-0.14x ² NS
between strain heterogeneity	NS	+	NS	NS	+	+	NS	NS
Within-strain coef.								
A1077	1.7x **	-0.04x ² *	1.6x **	-0.04x ² +	10.1x **	-0.42x ² **	8.8x *	-0.36x ² *
A1066	0.5x NS	+0.01x ² NS	0.3x NS	+0.01x ² NS	- 2.4x NS	+0.08x ² NS	-5.1x NS	+0.15x ² NS
A9077	2.2x +	-0.06x ² NS	1.6x NS	-0.04x ² NS	12.8x NS	-0.53x ² NS	-6.4x NS	-0.31x ² NS
Hyper	0.3x NS	+0.02x ² NS	0.2x NS	+0.03x ² NS	1.6x NS	-0.04x ² NS	1.1x NS	-0.01x ² NS

a) Implantation sites and live embryos numbers (NI and NS).

With a linear adjustment, the average regression coefficients of NI and NS on NO were highly significant :

$$\beta_{NI/NO} = 0.80 \pm 0.05 \quad ; \quad \beta_{NS/NO} = 0.70 \pm 0.06$$

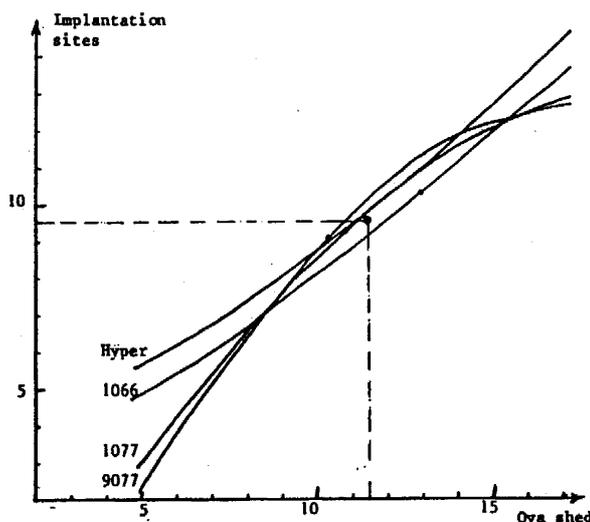
Figure 1 :
Linear regressions of
(1) implantation sites number
(2) live embryos number
on number of ova shed
in the four strains studied



Heterogeneity of slopes between strains was not significant. There were no differences for the ordinate at origin between strains (no significant strain effect on NI or NS in model 2), so the 4 regression lines were not significantly different (fig.1).

With a quadratic adjustment, the linear term was significant on both variables, without between strain heterogeneity. In the aggregate, the quadratic term was not significant but there was a trend for NI to an heterogeneity of coefficients between strains. The quadratic coefficient was significantly negative in the strain A1077 and displayed a similar value, although not significant, in the 9077. It was close to zero in the two other strains (fig.2). For NS, the between-strain heterogeneity of quadratic coefficients was not significant, but the trend was similar to that for NI (Table 4).

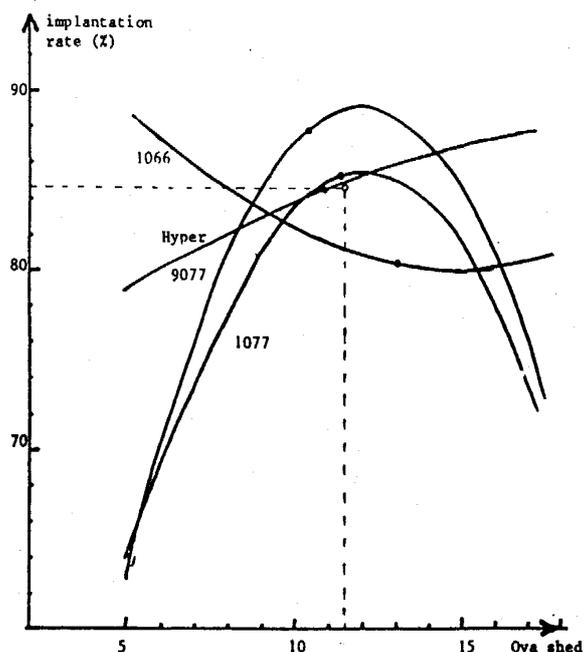
Figure 2 :
Polynomial adjustments
in the four strains



b) Implantation rate (IR) and rate of embryonic survival (SR).

The coefficients of the linear regression of IR and SR on NO did not differ significantly from 0 : these rates were not linearly related to NO. This was congruent with the type of relationship observed between NI (or NS) and NO ($y = a \cdot x$). The linear regression of NI (resp. NS) on NO (0,80 resp. 0,70) was in accordance with the mean value of IR (resp. SR). In the quadratic adjustment, the linear and quadratic terms for IR were significant ($p < 0,10$) and so was the heterogeneity between strains (fig.3). This was essentially due to the strain A1077 whose coefficients differed significantly from zero and to the strain A9077, with similar but not significant coefficients. For the strains A1066 and "Hyper" the coefficients did not differ from zero.

Figure 3 :
Polynomial adjustments
in the four strains



These results suggested a repartition of the four strains into two groups : on one hand, the strains originating from the New-Zealand White breed (A1077 and A9077) tended to a plateau for NI and NS while NO increased. On the other hand, the strains A1066 and "hyper" did not follow this law of diminishing returns.

DISCUSSION AND CONCLUSION

The increase of ovulation rate and the decrease of embryonic survival with parity was congruent with the general results of literature for polytokous species (swine, mouse and rabbit), reviewed by RINALDO (1986). The direct heterotic effect observed here (difference between purebred and crossbred embryos) was about 5 to 10 % and was in accordance with the average value reported by MATHERON and MAULEON (1979).

With respect to the relations between ovulation rate and embryonic survival, two patterns were observed within our four strains : a linear or a curvilinear relation. As for number of sites or embryos, however, a quadratic adjustment did not improve the determination coefficient very much, compared to the linear one. In rabbits, references are scarce. GARCIA et al (1983), exploring the linear relationships between NS and NO, found a

coefficient β very close to ours (fig.1), in strains issuing from the same breeds as ours. The existence of a between-breed variability of the relation between ovulation rate and embryonic viability has already been observed in sheep (RICORDEAU, 1988) and in swine (BOLET, 1986).

The existence of these two patterns of relationship between number of embryos and number of ova shed, if it was confirmed at a genetic level, could induce two different selection strategies for litter size improvement. If the relationship is linear, a selection on number of ova shed may prove more efficient, providing that heritability and genetic correlation were favourable. With curvilinearity, alternative strategies would have to be looked for according to the mean value of ovulation rate and embryonic viability in the population.

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Data from 4 experiments have been analyzed in a whole. They concerned the components of litter size of does autopsied about the 14th day of pregnancy (D14) : number of ova shed (NO), of implantation sites (NI) and of live embryos at D14 (NS), implantation rate (IR = NI/NO), and rate of embryonic survival (SR = NS/NO). 360 pregnant does from 4 genotypes have been analyzed : the INRA strains "1077" and "9077", issuing from the New-Zealand White breed, the strain "1066", coming from the Californian breed and a synthetic strain called "hyperfertile". Variance and covariance analysis have been performed, including fixed effects ("doe strain", "embryo type" - purebred or crossbred-, "experiment" and "litter parity"), either with or without a regression on NO (linear and quadratic ; global and intra-strain). The analysis confirmed the significant superiority of the strain "1066" over the 3 others with respect to NO. No significant difference between strains was found with respect to NI, NS, IR and SR. The type of embryos had not a significant effect on any component. NO increased significantly with parity, while IR and SR decreased. In all strains, NI and NS displayed the same linear relationship with NO ($\beta = +0.80$ and $+0.70$ respectively). IR and SR displayed a curvilinear relationship with NO in the 2 strains of New-Zealand White origin.

**RELATIONS ENTRE TAUX D'OVULATION ET SURVIE
EMBRYONNAIRE DANS DIFFERENTES SOUCHES DE LAPINS**

Nous avons analysé globalement 4 expériences concernant les composantes de la taille de portée de la lapine autopsiée vers 14 jours de gestation (J14) : le nombre d'ovules pondus (NO), d'implants (NI) et d'embryons vivants (NV), le taux d'implantation (TI = NI/NO) et le taux de survie embryonnaire à J14 (TV = NV/NO). L'analyse concerne 360 lapines gestantes, issues de 4 souches : les souches INRA "1077" et "9077", originaires de la race Néo-Zélandaise Blanche, la souche INRA "1066", de race Californienne et une souche synthétique dite "Hyperféconde". Les modèles statistiques utilisés sont des analyses de variance et covariance, avec les effets fixés "souche de femelles", "type d'embryon" (pur ou croisé), "expérience" et "numéro de portée", avec ou sans regression sur NO (linéaire et quadratique ; globale et intra-souche). L'analyse confirme la supériorité significative de la souche 1066 sur les 3 autres pour NO. Par contre, elle ne révèle pas de différences significatives entre souches pour NI, NV, TI et TV. L'effet "type génétique des embryons" n'est jamais significatif. NO augmente significativement avec le numéro de portée tandis que TI et TV diminuent avec lui. Pour NI et NV, la liaison avec NO est significativement linéaire ($\beta=0,80$ et $0,70$ respectivement) et indépendante de la souche. L'analyse de TI et TV met en évidence une liaison avec NO à tendance curvilineaire dans les 2 souches d'origine Néo-Zélandais Blanche.

