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Crossbreeding experiments on meat rabbits in Northern Mediterranean Countries: a survey

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SUMMARY - Intensive rabbit production is highly dependent on crossbreeding. Commercial strains capitalize heterosis and complementarity effects. The most important aim of research is the characterisation of the economic resources in populations and breeds, or strains selected from breed, or synthetics. Some experiments carried out in Stations in France, Italy and Spain are reviewed in this paper. Productive and reproductive characters are examined and analyzed separately. The growth traits can be modulated according to the genetic direct potential of the sire, increasing carcass weight at fixed age or exploiting younger conditions at fixed weight. Crossbreeding New Zealand W. and Californian does by Giants or medium sized European bucks is generally associated with reduction of fat, skin and liver, when the carcass weight is held -statistically- constant. The growing period can be strongly reduced with improved efficiency. Feed efficiency ethiology has to be further investigated. Litter size is a very important trait to be studied. Mortality facts are often involved in the resulting breed differences in the net averages of litter size at weaning, also in their genetic components. Thus mortality should be properly taken into account in future experiments. The development of new strains in Northern Mediterranean area using natural or artificial recombination will require deeper research. Rabbit will be an excellent tool for production purposes and serve as a model for domesticated mammals.

Key words: Rabbit, crossbreeding, breeds.

RESUME - "Essais de croisement sur des lapins à viande dans les pays du Nord de la Méditerranée : tour d'horizon". La production intensive du lapin dépend dans une grande mesure des croisements. Les souches commerciales bénéficient largement des effets d'hétérosis et de complémentarité. L'objectif primordial de la recherche est la caractérisation des populations et espèces, et également des souches sélectionnées à partir d'une espèce, ou bien synthétiques, en ce qui concerne les aspects d'importance économique. Nous passerons en revue quelques expérimentations menées dans des Stations en France, en Italie et en Espagne. Les caractères de production et de reproduction sont examinés et analysés séparément. Les caractères de croissance peuvent être modulés selon le potentiel génétique direct du mâle, et l'on peut ainsi augmenter le poids de la carcasse à un âge donné ou améliorer les performances des jeunes pour atteindre un poids fixé. Lorsque l'on croise des femelles Néo-Zélandaises Blanches et Californiennes avec des mâles de race Géante ou Européens de taille moyenne, en général, la quantité de gras, de peau et la taille du foie diminuent, en pourcentage du poids total de la carcasse. La période de croissance peut se voir fortement réduite grâce à une efficacité meilleure. La recherche devra se poursuivre dans le domaine de l'éthiologie de l'efficacité alimentaire. La taille de la portée est un caractère très important qu'il faudra étudier. La mortalité est un aspect qui fait partie des différences entre races reflétées dans les moyennes nettes de taille de la portée au sevrage, et qui a une composante génétique. Par conséquent, cette mortalité devrait être considérée comme il se doit dans les expériences ultérieures. Des recherches plus approfondies devront être menées afin de mettre au point de nouvelles souches dans les pays du Nord de la Méditerranée, en utilisant la recombinaison naturelle ou artificielle. Le lapin est un excellent sujet pour la production et un bon modèle pour les mammifères domestiques.

***Mots-clés:** Lapin, croisement, races.*

Introduction

In rabbit production, intensive breeding systems are closely linked with crossbreeding exploiting the gene pool. All the commercial "hybrids" are built by simple or complex crossing of strains or breeds, virtually selected with negligible (or wanted) inbreeding. Some Italian examples exist of small complete selection units. The basic female line of the 'farm strains' for meat production is generally issued from New Zealand White sporadically renewed from their cradle. In Italy, (ANCI-AIA, 1989) this kind of females is not negligible

-nearly 19%- while in France is 25% (ROCHAMBEAU, 1988). Some Italian producers aim - or need - to build their own field strains from New Zealand (N) or Californian, (C) including commercial hybrids.

In these synthetic strains segregations have not dramatic effects: from field opinions confirmed by Spanish experiments (BASELGA and BLASCO, 1989) the stabilisation of productive strains is possible. However this fact should be carefully quantified directly in adequate experiments, at multiplication and production levels.

In the early 1980's the main axis of selection strategy seemed to be the intensification of breeding rhythm without decreasing longevity. Ten years later the breeding goals moved to an overall litter size trait (born, weaned, sold). At the management level the longevity of the does is somewhat balanced by early breeding and high renewal rate per year, substantially higher than 100%. The lowering of breeding schedule is balanced by increasing the number of the waiting cages and of the active females. Moreover the reduction of the antagonism milk-reproduction allows simplified diets.

Some differentiated categories (2,3 - 2,6 kg) now occur in Italy and France.

In the experimental public Stations some efforts were made in order to characterize breed economic resources, and sometimes, in the big Stations, to achieve specialized strains both for experiments and for massive improvement purposes.

On the other hand the Technico-Economical Management active in Europe with herd summaries (France - Spain) or with individual recordkeeping of reproductive performances (France, Spain, Italy (ANCI-AIA, 1990)) allow some opinion on the genetic state of the art i the rabbit meat production.

Productive traits

The existence of some forty European breeds suggests to look for the best combinations between them. The first step is a preliminary evaluation of the performances of the single breed and possibly of some multiway joint-breeds.

Genetic experiments very often aimed at ranking breeds or strains as sire for crossing, but systematic studies of the combinations which could be obtained were far from reality. New trials attempted to characterize some existing strains. The material grouped in this report is referred to a common NZW (N) and/or CAL (C) basis (table A).

The traits considered (table B) were the following: weaning weight (WW), average daily gain (ADG), daily feed intake (ADF), feed conversion ratio (FCR) or the feed intake regressed on daily gain (BRUN and ROUVIER, 1988). Another trait related to growth is the Feed Constant Weight (FCW), that is the estimated amount of feed ingested by the animals between two fixed body weights (MASOERO *et al.* 1985).

THE FRENCH EXPERIMENTS

In Toulouse some specific strains from N and C populations have been raised for decades, according to ROUVIER (1971 and 1973), CENTIS (1972) and BRUN and ROUVIER (1988). Table 1 shows a relative prevalence (5 to 10%) in absolute growth of N vs C. In these experiments N improved feed efficiency only once; otherwise at fixed ages the two traits were only little related. A remarkable case was the N unselected control strain (BRUN and ROUVIER, 1988), which was less efficient because of the higher appetite due to greater mature weight and probably higher maintenance requirements: at slaughtering the kidney fat (KFW) in the carcass was minimum in the selected N strain vs the unselected N and also vs C. The authors pointed out some appreciated qualitative characteristics of the carcasses from C sire.

In the other breeds reared and studied in Toulouse, with respect to C, the ADG in the usual period 30-70/77 d was nearly alike in the Silver (SF) and lower in the Burgundy Fawn (BF) (Tab. 1-a), while the growth appeared relatively more efficient. However, these results were apparently reversed (Tab. 1-c). The Bouscat Giant (BG) confirmed higher growth potential and efficiency.

The classical experiment of OUHAYOUN (1978) (Table 2) emphasized the patterns of the expected inequalities of medium sized towards half giant or half dwarfed types; C was not ranked, so the differences to N were around 3% for ADG in the medium sized and over 10% in the Giants, but the crude feed efficiency apparently did not improve at that fixed time interval. The meat qualities (meat/bone ratio from hindlegs) paradoxically converged in Flemish Giant (FG) and Small Russian (SR): both 9% higher that N, while BG diverged -4%. This particular point requires to be confirmed: in effect we disagreed (MASOERO *et al.*, 1985, Tab 5): no effect on meat/bone ratio when FG bucks were mated to N and C does. On the contrary, when some bucks F1 from FG and N were remated to N and C does then the meat/bone ratio was significantly decreased by approximately 7% (AUXILIA and MASOERO, 1986).

The classic paper of ROUVIER (1970) (Table 3) on additive variability of slaughter traits and anatomical composition of BF, SF and Grand Russian (GR) also compared the strains:

— the dressing % (equivalent variable) ranked SF > BF > GR;

— the skeleton weight was lighter in SF;

— the fat content was higher in SF and BF;

— equality for muscle contents or muscle/bone ratio.

Diversity in medium sized strains was effective: CHERIET, et al. (1982) (Table 4) in a memorable paper tested the selected strain INRA 1027 against local rabbits in three feeding conditions: at 2400 kcal DE, Crude Protein was: 17,3; 13,5 or 10,4% . The growth, the FCR and the body composition were quite different, but never interacting with the diets. The relative advantage of purebred selected strains, compared to purebred, was 7% for ADG and -6% for feed efficiency (wastaging groups excluded: 3,25 vs 3,47 g/g) -3% as kcal DE /g of gain (7,95 vs 8,18) and +9, +11% for muscling traits.

Knowledge from Spain

Spanish contribution is suited to study the meat traits of Giant strains. Paradoxically, the normal slaughter weight in Spain at 60-70 d is certainly the lightest in Europe: 1,9 kg. So the early mature types should be preferred (BASELGA and BLASCO, 1989). The Valencia team worked on purebreeding as well as on the knowledge and prediction of meat and bone contents (BLASCO *et al.*, 1984) and on allometric functions. Data from BLASCO (1982) confirmed around 7% of superiority for N vs C in ADG. Strain differences were found (DELTORO, LOPEZ, CAMACHO, 1988) to exist between N and C strains, being limited to the fat of the total carcass, not concerning the protein nor the water contents.

Experiments in Italy

After the review previously given (MASOERO, 1982) and the summaries implemented by ROCHAMBEAU (1988) some new Italian sources are available: papers from scientific and technical bulletin as well as some thesis from the University. At the Ministry of Agriculture Experimental Station located in Turin, three crossbreeding experiments from 28 subgroups were carried out on 15 genetic types of bucks and C and N females. At slaughter, 245 rabbits from the 603 controlled were measured. The first experiment was partially complemented by ORLANDI (1985) with 6 genetic types. The second trial was even replicated by RAIMONDI (1988) who utilized the same type of F1 bucks. GRANDI and STEFANETTI (1987) studied the possibility of N, C and Vien Blue (VB) crosses.

A critical point is the definition of the comparison groups: as N and/or C were always on trials all the available purebred and reciprocal (diallel) can be pooled (=N&C) as unbiased means of reference of the additive genetic value. This is inclusive of the eventually no-zero non additive effects in the sense of DICKERSON (1969). In total 8 breeds were compared as sire, or as paternal grand sire in F1 bucks by some 18 cells. The tables 5.2 and 5.3 give the means of references of the N&C pools.

Surveying by breed

BF - Burgundy Fawn: higher in WW, varied in ADG performance but more efficient in constant weight basis. The carcass performances are not stable, probably it is fat and liver reducing with unconstant results in conformation.

SF - Silver French: increasing sometimes WW and ADG perhaps because of high variability within breed, efficient on growth (FCW). As carcass, it is remarkably higher in dressing % (HDP) and exceptionally increasing the fatness (KFW).

VB - Vien Blue: good performance in WW as sire, but not as grand sire being however good in ADG; voracity is increased but not always linked to improved efficiency (FCW); the skin weight is reduced even in F1 (grand-sire effect) and the fat is largely reduced as well as the liver weight; carcass length (CL) was increased but the conformation remained good.

T - Turingia, a precocious breed: increasing WW, reducing ADG and ADF with lower efficiency on time basis as we can also see from the high degree of fatness in the carcass. Other signs of precocity are lower gastro-intestinal tract (GITW) and skin, while the hot dressing % (HDP) increased. The carcass is longer but with good conformation.

CG - Chinchilla Great: appreciated as sire, not as grand sire; in carcass both types are neutral to HDP and seem to be lowering in fat and liver weight. The conformation remains good.

L - Lops: highly variable results between experiments and among genetic types, however the FKW seemed to be better. The carcasses are strongly lengthened.

GS - Giant Spotted: its good aptitudes seem to disgregate when F1 bucks were served. Good as sire for growth and related efficiency (FCW). Skin weight reduced but GITW weight increased so the HDP was unchanged.

FG - Flemish Giant: as sire in 1 experience it was tremendous in ADG (26%) and in feed efficiency (-8% in FCR and -23% in FKW); average in HDP (balanced by lower skin weight vs higher GITW), surely reduces fat and gives thin carcasses. As grand sire it was negative for HDP and again reduced skin weight but the carcass was unchanged. The compactness was reduced.

A general pattern is the almost constant reduced skin weight (when differences of carcass methods are considered) and the pertinent thickness and hair coat density. This is not free of consequences as practical breeders know. Also the liver weight skips down, which causes or consequences remain unknown. Yet carcass fatness is strongly delayed by rabbit crossbreeding with apparent exception for Silver French. The shape of carcasses was lengthened probably because of bone length. Thus compactness is generally reduced. The feed efficiency and growth-related characters appear to be strongly depending on time to mature (commercially) with favourable economic consequences.

Phenotypic and genetic effects on litter size

A very important point to be stressed is litter size in populations, breeds or strains, given the complexity of the compound trait analytical methods needed to investigate the biological components.

THE INRA SCHEMES

The French Task Force of Rabbit Research has for a long time investigated and selected three specific strains: INRA 1066 (C+Grand Russian), INRA 1077 (N), INRA 1089 (SR+Dutch) (MATHERON and ROUVIER, 1978). The smaller maternal strain is very fertile as female: 75.3 vs 63 (N+C) according to POUJARDIEU and VRILLON (1973), but also good as sire: 73 vs 58 and 68 % for C and N respectively (Table 6). Preweaning mortality raised in C dams (23 vs 15%), which seems to be a constant for this strain. Nevertheless biological specificities often did not perfectly agree with easy raising: that is well known in all Giant types, rabbits or poultry or others, as well as in dwarfed or smalled types. Thus INRA 1089 was employed as further line to create F2 "maternal" self-renewed females.

The other two maternal strains at Toulouse are selected for numerical productivity. Monitoring of genetic evolution is pursued periodically in Station (diallel crosses) while on the field only some combinations are performed: at multipliers level (sire 1066 x dam 1077) or at demultiplier level (1066 x 1077). From the many papers devoted to this topic, already analysed and summarized by BRUN and ROUVIER (1988) and ROUVIER and BRUN (1988) some capital points are fixed. In Table 7.1 the summary of 1970's data, concerning some 4954 born alive (BLS) are reported. The two generations of each experiment are overlapped. In the cells the means of the litter size at birth and weaning are reported. On the right side the two mortality rates (in negative sign) are reported: the first resulted from deleting litters with zero weaning (upper) (1-WLS(weaning)/BLS(kindling); the second is the crude or total mortality rate, including litters with no weaned kit (lower). The bias in the first mortality index is evident. The correlation birth-weaning is not perfect because total or partial losses of litters did not occur equidistributed. The genetic effects according to DICKERSON (1969) are not significant for the litter's traits at birth, except for the maternal heterosis which appeared only in 1980. This may be explained by the 70/80 comparison because the F1 litters grew relatively more (14%) than purebred (8% or less). In the productive life this maternal heterosis disappears.

On the contrary at weaning (i) the individual heterosis remains stable and high (11 and 8%), while (ii) genetic individual effects reach a significant level (0.70 for N). Genetic grand maternal effects from 0.66* reversed to -0.22* (iii), while genetic maternal effects from -0.98* increased to -0.12 (4). These changes in components of WLS may be well explained in terms of evolution -or floating peaks- in mortality, nevertheless, the exposed overall values were however very low. In Table 7.2 is reported an alternative Log-Linear model (Proc CATMOD in the SAS package, 1987) of frequencies in mortality rate, the factors being S (sire) of litter, PGS (Paternal Grand Sire) and MGS (Maternal Grand Sire) of litter, as well as their interactions. When comparing '80 vs '70 we can observe a reverse in the PGS rank because of a strong lowering in N classes: this fact explains the point (ii).

STRAINS IN VALENCIA

In Spain (ESTANY, 1988) summarized differences for the N vs C strictly purebred strains of Valencia team as overall: BLS and WLS, respectively for N and C averaged: 7.16 ; 5.77 and 8.71 ; 7.02 (zero weaned included), thus WMR was perfectly alike (19.4%). A superiority for C of more than 20% can derive from the original genetic basis and not from selection as the response to selection was nearly zero.

REPORTS FROM ITALY

Differences in WLS (a good predictor of the numerical productivity) were reported for one herd in Italy (MASOERO and AUXILIA, 1986: N= 954 litters), as before: 6.62 ; 7.22 and 5.90; 6.17, thus WMR being 11 vs 15%. Better "birth ability" was confirmed for C vs maternal aptitudes for N.

To test a simple renewal model and to estimate genetic effects, a criss-cross experiment lasting four generations was carried on at Turin (Tables 8, MASOERO and NAPOLITANO, 1991) involving 1789 litters of does derived from N & C and also 383 from a contemporaneous terminal synthetic strain (TT). The data were corrected for environmental variations in a year-quarter physiological basis. This experiment was particular because we entered only 6 bucks from an unknown C strain (sampled from small breeders). Thus some cells were missing. We observed interactive effects on WLS. The genetic effects were estimated by simple regressive models because inversion of the whole matrix was impossible. Additive genetic effects at birth were apparently unfavourable to N (-0,54* BLS vs C as direct and -0.71** as maternal effects). In the preweaning phase individual genotype N, or maternal genetic origin N, contrasted pre-weaning mortality (-0.42** died) thus the net effect on WLS for N was apparently only -0.11 as direct effect and -0.29 as maternal. Non additive individual effects were present, but only as individual recombination (1.23 *** BLS) not as heterosis. Non additive maternal effects were apparent as heterosis at birth (0.61***) but disappeared at weaning (0.20). The chief evidence from this criss-cross experiment was the appearence of individual recombination favourable to birth litter traits. When the favorite individuals became grand-mothers, in the III generation, the recombinative grandmaternal effects were also effective over the weaning traits (1.06** BLS and 0.81* WLS).

These genetic effects agree with a better performance of does 5/8 N that is, the (N(C(CN))). Could these results be continued and repeatable ? Further trials on station or in field could be undertaken.

Conclusions

Crossing is popular in many cases. Heterosis and complementary effects on the production cannot be neglected. In breeding and selection on the other hand, the immigration and inbreeding require to be investigated, the purpose being the replication of strains. The building of new strains by natural or artificial recombinations will certainly increase the need for deeper research. Litter size traits as well as other traits concerning the fitness in the artificial intensive environment must be examined first. Also feed efficiency ethiology has to be investigated: the approach between breeds could be very appropriate especially if genetic causes may be displayed till the recombination effects.

Rabbit will be an excellent tool both for production and as a model for domesticated mammals.

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Table A. Abbreviations of the name of the breeds and strains

BG	Bouscat Giant	N	New Zealand White	NU	Unselected N
BF	Burgundy Fawn	SF	Silver French		
C	Californian	SG	Spotted Giant		
CG	Chinchilla Great	SR	Small Russian		
FG	Flemish Giant	T	Turingia Chamois		
VB	Vienna Blue				

Table B. Abbreviations of the used variables.

BLS	Birth Litter Size (alive)	BMR	Birth Mortality Rate
WLS	Weaning Litter Size	WMR	pre-Weaning Mortality Rate
LW28	Live Body Weight at 28 d	LSW	Live Slaughter Weight
ADG	Average Daily Gain	HDP	Hot Dressing Percentage
ADF	Average Daily Food Intake	SKINW	Skin Weight
FCR	Feed Conversion Ratio	GITW	Gastro-Intestinal Tract Weight
FCW	Food at Constant Weights	KFW	Kidney Fat Weight
		LIVERW	Liver Weight
		CL	Carcass Length
		LG	Loin Girth (carcass)

Table 1. Ranking of medium sized strains at the Toulouse Centre (as % deviate from 100).

REF	SIRE	DAM	N	Variables			
				LW28	ADG	ADF	FCR
a, b	N	N	136	4	5	•	-13
		C	•	•	•	•	-15
	C	C	111	571	34,8	•	3,58 = 100
		N	•	•	•	•	-9
	SF	SF	64	8	-2	•	•
		N	•	7	6	•	-11
		C	•	•	.	•	-11
	BF	C	•	0	0	•	-10
		BF	•	-13	-10	•	•
		N	•	•	•	•	-8
	BG	N	•	•	•	•	-16
		C	•	•	•	•	-12
c	N	.*	102	5	10	8	-2
	.*	N	211	11	7	7	-1
	C	.*	93	497	30,5	103	3,38 = 100
	.*	C	157	9	6	6	0
	BF	.*	98	17	3	5	2
	SF	.*	71	6	7	8	0
	BG	.*	60	6	10	8	-2
d	N	N	34	-6	7	2	-1
		C	35	6	1	5	4
	C	C	39	567	31,8	96	2,90 = 100
		N	42	12	7	9	7
	NU	NU	60	9	8	9	6
		N	37	2	6	4	2
		C	33	-4	7	9	6

(NU = New Zealand Unselected, N = A1077, C = A1066).

a) ROUVIER, 1971. b) ROUVIER, 1973. c) CENTIS, 1972. d) BRUN and ROUVIER, 1988.

Table 2. Terminal sires of different adult size mated to INRA 1067 (C. N.) does: the Ouhayoun's experiment (1978) (relative difference to INRA 1077 sire).

	Sire adult weight,kg	Rabbit mature weight	LW28	ADG (28-77)	FCR	Meat/ bone	Compact. g/mm	Maturity % at 77d
BG	5,3	4,35	19	16	0	-4	10	-4
FG	5,8	4,70	0	10	2	9	8	-17
RexHabana	3,5	3,55	12	3	2	2	3	8
INRA 1027	3,8	3,70	-4	3	0	2	2	0
INRA 1077	3,7	3,65	656	37,5	3,6	5,6	2,3	68,3 = 100
INRA 1089	2,8	3,70	7	-9	8	9	-4	8
Polish	1,7	2,60	-1	-26	25	11	-10	11

Note:
INRA 1027= 4 breed synthetic line, selected for ADG.
INRA 1077= N unselected (NU) = control line.
INRA 1089= (Dutch x SR) maternal line.

Table 3. Body composition (%) of French breeds (ROUVIER, 1970)

Genetic type	SLW	HDP	Muscle	Bone	Fat	Meat/Bone
BF	2140	63,6	57,3	13,3	6,3	4,31
SF	2460	64,6	58,6	12,9	6,7	4,54
GR	2055	62,6	56,9	14,2	5,7	4,01

Table 4. Selected vs local rabbits on different diets (CHERIET et al. 1982).

Breed	Diet	ADG		ADF	FCR		DE/ADG		Meat, g		Meat/Bone
INRA 1027	Normal	37,0		121	3,28		7,95		160		5,8
	Mixed	-2		-4	-2		0		-5		-5
	Hard	-22	.	22	2	x	2	x	-22		-5
			7			-6		-3		9	
Local	Normal	-8		1	9		4		-10		-12
	Mixed	-7		-4	2		2		-11		-12
	Hard	-28		.	.	x	.	x	-30		-17
			31,9			3,46		8,18		133	

The means are expressed as % of the first subgroup, and reciprocally as deviation of the selected strain from the local (x group deleted).

Table 5.1. Survey of recent Italian experiments in crossbreeding: material and methods.

Ref	Sires	Dams	N live/slaugh.	d1-d2	SLW	REF.
a	N, C, BF, SF, VB, FG	N, C	225 / 84	35-84		MASOERO et al., 1985, 1986
b	N, C, T, GS, VB. C, FG. N	N, C	212 / 89	41-77		AUXILIA et al., 1986
c	N, L, CG, GS. N	N	168 / 36	32-74	2450	AUXILIA, 1988
c'	N, L, CG, GS. N	"	/ 36	"	2800	MASOERO, 1987
d	N, C, BF, SF, L	N	60 litters / 120	45-85		ORLANDI, 1985
e	N, L. N, CG. N, SG. N	N	76 / 76	40-90		RAIMONDI, 1987
f	N, C, VB	N	99 litters / 72	28-77	2400	GRANDI et al., 1987
			~2000 / 437			

Table 5.2. Survey of recent Italian experiments in crossbreeding: growth traits (prevalence as % to reference C & N, reported below).

		Variables				
BREED	REF Tab 5.1.	LW28	ADG	ADF	FCR	FCW
Burgundy Fawn						
BF	a	13 *	10 *	6,3	2,8	-10
	e	8	-11	-8,0	0,0	-6
Silver French						
SF	a	22 *	11 *	11,0 *	0,0	-11
	e	0	-5	-12,0	-11,0	-10
Vien Blue						
VB	a	11 *	11 *	9,0 *	-1,0 *	-9
	f	3	3	5,0	3,0	
	b	-11 *	5 *	7,0 *	2,0	3
Turingia Chamois						
T	b	9	-6 *	-3	5,0 *	2
Chinchilla Great						
CG	c	0	5	0	-4	-6
CG.N	d	-2	-4	-6	-2	
Lops						
L	c	7	6	1	-4	-10
	e	-6	-9	-6	-3	-12
L.N	d	5	-6	0	5	
Giant Spotted						
GS	b	3	10 *	6 *	-3	-10
GS.N	c	-8	-4	-6	-2	0
GS.N	d	3	7	-6	-2	
Flemish Giant						
FG	a	16 *	26 *	15	-8 *	-23
FG.N	b	0	-5	-5	-1	2

Note: The pointed types are F1 bucks.

Table 5.2. continuation. Means of reference.

REF	Sire	Dam	Means of reference				
a	N	N	797	33,0	142	4,21	7239
		C	767	30,7	137	4,48	8081
	C	N	741	33,0	140	4,25	7603
		C	737	34,3	151	4,43	7774
	Mref		760	32,7	142	4,34	7674
	Se		120	3,86	15,1	0,38	791
b	N	N	961	38,0	120	3,17	5469
		C	911	38,9	128	3,29	5703
	C	N	1029	39,9	126	3,18	5275
		C	846	37,7	113	2,99	5501
	Mref		934	38,6	122	3,16	5487
	Se		145	48,7	18,2	0,40	699
c	N	N	764	41,3	136	3,34	5895
	Se		139	6,53	16,8	0,43	1009
d	N	N	959	32,6	141	4,33	
e	N	N	992	34,9	151	4,36	5760
	C	N	1177	36,1	143	3,70	
	Mref		1084	35,5	147	4,03	
	Se		150	3,72	5	0,42	
f	N	N	573	34,6	118	3,41	
	C	N	586	34,8	121	3,47	
	Mref		580	34,7	120	3,44	
	Se		63	3,7			

Table 5.3. Survey of recent Italian experiments in crossbreeding: carcass traits (prevalence as % to reference C & N, below).

BREED	REF Tab 5.1.	SKINW	GITW	HDP	KFW	LIVERW
Burgundy Fawn						
BF	a	-10 *	0	2 *	-9	-8
	e	16	-10	-2	.	.
Silver French						
SF	a	-11 *	0	3 *	3	-8
	e	11	5	5 *	.	.
Vien Blue						
VB	a	-6 *	0	1	-26 *	-20 *
	f	-5	4	0	-8	-6
	b	-4 *	3	0	-15	-8
Turingia Chamois						
T	b	-5	-4	3	7	-5
Chinchilla Great						
CG	c	-4	-8	-1	-4	-11
	c'	-7	6	0	-10	-9
CG.N	d	-7	-6	5	.	6
Lops						
L	c	0	-6	-1	-6	-19
	c'	-12 *	0	3	-16	-15
	e	6	3	-2	.	.
L.N	d	3	-9	6	.	.
Giant Spotted						
GS	b	-7 *	8 *	0	-30 *	0
GS.N	c	-4	5	-2	1	-8
	c'	-10 *	12	2	-1	-6
GS.N	d	-2	3	5	.	.
Flemish Giant						
FG	a	-10 *	6 *	0	-32 *	-10
FG.N	b	-8 *	17 *	-4 *	-26 *	5

(SKINW, GITW, HDP, KFW, LIVERW: Variables)

Table 5.3. continuation. Means of reference.

		SLW	SKINW	GITW	HDP	KFW	LIVERW
REF.	a	2569	424	416	60,8	34	102
	b	2564	425	445	60,0	27	92
	c	2454	389	483	59,5	27	96
	c'	2941	497	504	57,0	33	100
	d	2587	390	621	62,7	.	.
	e	2590	238	571	56,9	.	.
	f	2405	370	374	62,0	15,5	89,6

Note: The pointed types are F1 bucks.

For REF. see table 5.

Table 6. Report on C, N, SR strains at Toulouse (POUJARDIEU and VRILLON, 1973).

SIRE		DAM			
		C	N	SR	Sire's av. ge
C	N'litters	39	90	27	
	Conc. Rate %	56,2	55,9	73,2	58.4
	BLS	6.18	6.75	6.8	6.42
	WLS	6.18	6.75	6.8	6.42
	WMR %	20,3	15,1	71,1	17,5
N	N'litters	23	64	55	
	Conc. Rate %	57,1	63,3	78,6	67,6
	BLS	7,55	7,95	7,61	7,72
	WLS	4,76	6,66	6,59	6,2
	WMR %	37,0	16,2	13,4	19,7
SR	N'litters	51	84	65	
	Conc. Rate %	73	73,4	73,1	73,2
	BLS	7,11	7,98	6,16	7,12
	WLS	5,83	6,95	5,1	5,98
	WMR %	18,0	13,1	17,1	16,0
Dam's Av. ge					
	Conc. Rate %	62,9	63,5	75,3	66,5
	BLS	7,49	7,97	7,15	7,56
	WLS	5,76	6,8	6,04	6,19
	WMR %	23,1	14,7	15,6	16,0

Table 7.1. Crossbreeding experiment in selected strains at Toulouse Centre: the 1970 experiment and its replication ten years later.

SIRE	1970	DAM CC		NN		C.N		N.C	
C	BLS	7,31	-10 % a	7,44	-10 %				
	WLS	6,56	-25 % b	6,73	-23 %				
N	BLS	7,77	-5 %	7,13	-13 %				
	WLS	7,37	-17 %	6,17	-23 %				
BF	BLS	7,70	-13 %	7,94	-10 %	7,95	-8 %	7,55	-21 %
	WLS	6,72	-23 %	7,18	-16 %	7,32	-17 %	6,00	-30 %

a) Apparent Mortality Rate: WLS/BLS-1
b) True Mortality Rate (from total of subclasses)

SIRE	1980	DAM CC		NN		C.N		N.C	
C	BLS	7,81	-27 %	8,08	-17 %				
	WLS	5,71		6,69					
N	BLS	8,26	-16 %	8,03	-4 %				
	WLS	6,92		6,87					
BF	BLS	8,73	-13 %	8,02	-14 %	9,16	-8 %	8,6	-21 %
	WLS	7,58		6,89		7,71		7,72	

Estimated genetic effects (BRUN and ROUVIER, 1984, 1988)

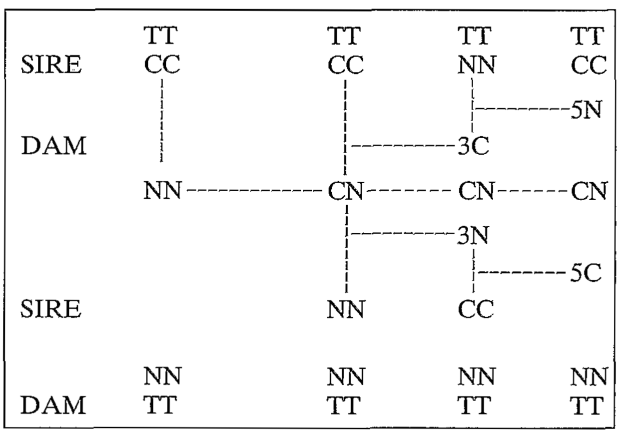
		ADDITIVE gI (N)	gM (N)	gM' (N)	NON ADDITIVE hI (%)	hM (%)
1970	BLS	0,08	-0,36	0,20	5	3
1980		0,20	-0,37	0,03	3	4 *
1970	WLS	0,12	-0,98 *	0,66 *	11 *	-4
1980		0,70 *	-0,12	-0,22 *	8 *	2

Note: WLS in this case does not include null litters.

Table 7.2. Analysis of mortality from 1970 experiment (table 7.1) by loglinear model.

MODEL	CLASSES	MEANS 1970		MEANS 1980
S	Breed of the sire of the litter	***	C>N>BF 24>21>19	C>N>BF 22>15>13
PATGS	Breed of the Paternal grandsire of the litter	***	C<N 20<22	C>>N 18>>14
MATGS	Breed of the Maternal grandsire of the litter	***	C>N 23>20	C<N 17>15
S * PATGS		ns	ns	
PATGS * MATGS		***	***	

Table 8.1. A criss-cross experiment on 4 generations: the scheme. (MASOERO and NAPOLITANO, 1991).



TT = synthetic terminal strain (BF + SF + N).

Table 8.2. A criss-cross experiment: the crude breed effects.

	N.° litters	BLS	WLS
DAM GROUPS			
NN	936	7,81	5,53
5N	138	8,75	6,46
3N	97	7,70	5,76
CN	362	8,10	5,65
3C	129	7,80	5,98
5C	127	7,43	5,10
TT	383	6,88	4,63
(P>)		***	***
SIRE GROUPS			
NN	1033	7,61	5,66
CC	225	7,63	5,28
TT	914	7,99	5,83
(P>)		*	+
Se		2,76	2,95
Interaction DAM*SIRE		ns	**

Table 8.3. Criss-cross experiment: genetic effects from corrected data. (additive effects expressed as difference C-N; non additive as absolute).

INDIVIDUAL EFFECTS			
	gI (N)	hI (N, C)	rI (N, C)
BLS	-0,54 **	-0,36	1,23 ***
WLS	-0,11	-0,16	0,41
MATERNAL EFFECTS			
	gM (N)	hM (N, C)	rM (N, C)
BLS	-0,71 ***	0,61 ***	0,12
WLS	-0,29	0,20	0,19
GRAN-MATERNAL EFFECTS			
	gMM (N)	hMM (N, C)	rMM (N, C)
BLS	-0,67 **	NOT EST	1,06 **
WLS	-0,69 **	NOT EST	0,81 *

Note: g = genetic, h = heterosis, r = recombinations effects.