Proceedings of the

4-7 july **2000** – Valencia Spain

These proceedings were printed as a special issue of WORLD RABBIT SCIENCE, the journal of the World Rabbit Science Association, Volume 8, supplement 1

ISSN reference of this on line version is 2308-1910
(ISSN for all the on-line versions of the proceedings of the successive World Rabbit Congresses)

EIBEN CS., SZENDRŐ ZS., ALLAIN D., THÉBAULT R.G., RADNAI I., BÍRÓNÉ NÉMETH E., LANSZKI J.

EFFECT OF DAM AND SIRE GENOTYPE ON REPRODUCTION TRAITS IN NORMAL-HAIRED, ANGORA AND THEIR SINGLE-CROSS RABBITS

Volume B, pages 591-596

EFFECT OF DAM AND SIRE GENOTYPE ON REPRODUCTION TRAITS IN NORMAL-HAIRED, ANGORA AND THEIR SINGLE-CROSS RABBITS

EIBEN CS.*, SZENDRŐ ZS., ALLAIN D.***, THÉBAULT R.G.****, RADNAI I.**, BÍRÓNÉ NÉMETH E.**, LANSZKI J.****

* Institute for Small Animal Research, P.O. Box 417, H-2100 GÖDÖLLŐ, Hungary
** University of KAPOSVÁR, P.O. Box 16, H-7401 KAPOSVÁR, Hungary
*** INRA Toulouse, SAGA, B.P. 27, 31326 CASTANET TOLOSAN, France
**** INRA Poitou-Charentes, Le Magneraud, B.P. 52, 17700 SURGÈRES, France

ABSTRACT

The effect on reproduction traits of maternal and paternal genotype was investigated in different mating combinations (NxN, AxA, F1xN, NxF1, F1xF1, AxF1) of purebred normal-haired rabbits (N), angoras (A) and crossbreeds of these (F1: progeny of NxA or AxN). Pregnancy rate and the size and weight of the litter at birth and at 21 days were determined primarily by the dam's genotype: performance of the N and F1 does surpassed that of the A females significantly. Presence of the angora gene reduces intrauterine viability, as, in contrast to the expected ratios, based on theory, of 3:1 for the F1xF1 group and 1:1 for the AxF1 mating, the proportion of normal-haired offspring proved to be higher, i.e. 80% ($P<0.05$) in the first and 60% ($P<0.001$) in the second mating combination.

INTRODUCTION

Angora rabbits show poorer viability, prolificacy and growth than normal-haired ones. The explanations for this include genetic factors and the effect of heat stress in connection with long wool (ROCHAMBEAU, 1988). There is, as yet, limited relevant literature confirming the adverse influence of angora blood and/or the supposed pleiotropic effect of the angora gene on reproduction and growth (DAMME *et al*., 1985; SHEN, 1992), since so far no experiments with a complete range of crossbred mating of normal-haired and angora rabbits have been performed.

In this series of experiments the objective was to clarify the accuracy of the hypothesis relating to the weaker performance of angora rabbits. The first step was to compare the diallel crossings (NxN, AxA, AxN and NxA; EIBEN *et al*., 1996ab) of purebred normal-haired (N) and angora (A) rabbits, to compare the reproduction of angora does inseminated with different semen (N, A and heterospermic N+A; EIBEN *et al*., 1999) and to investigate the effect on prolificacy in angora females of heat stress caused by long wool (EIBEN *et al*., 1997).

This paper reports on comparison of the full range of crossbreeding combinations of N, A and F1 rabbits (NxN, AxA, F1xN, NxF1, F1xF1, AxF1) based on their prolificacy traits.

MATERIAL AND METHODS

The experiment, involving 51 purebred normal-haired Pannon White (N), 31 purebred German angora (A) and their 65 crossbred (F1) rabbit does with 10 bucks in each genotype born from previous diallel mating (EIBEN *et al*., 1996b), was performed on the experimental farm of the University of Kaposvár. The does were first inseminated when they reached 80% of their adult weight (N and F1: 3.8-4.0 kg, A: 3-3.2 kg), i.e. at 154 to 161 days of age. The does were expected to produce at least three consecutive litters. Data on 115, 165 and 45

kindlings of N, F1 and A does respectively, in which a total of 2329 kits were produced from 437 inseminations, were evaluated (Table 1).

Table 1: Mating combinations, phenotype and genotype of the progeny

Mating sire x dam		No. of litters	Offspring day 21					Litter genetic background %	
	n		n	Pheno-type	Genotype, % NN	AN/NA	AA	N	: A
NxN	79	60	330	normal	100			100	0
F1xN	86	55	291	normal	50	50		75	25
NxF1	69	52	277	normal	50	50		75	25
F1xF1	65	58	207	normal	33	67		50	50
			64	angora			100	50	50
AxF1	73	55	160	normal		100		25	75
			107	angora			100	25	75
AxA	65	45	87	angora			100	0	100

The breeding animals were housed individually in flat-deck wire mesh cages (80x50x40 cm) in a closed building (16L:8D). The room was heated in winter by blowing in warm air (15 to 16°C), while in summer the inside temperature at times exceeded 25°C.

The breeding and growing animals were all fed the same commercial pelleted diet *ad libitum* (86% dry matter, 16.5% crude protein, 2.7% crude fat, 15.5% crude fibre, 0.70% lysine, 0.32% methionine, 0.60% Met+Cys, 10.3 MJ/kg De; pellet ∅ 3 mm). Drinking water was freely available from tipped self-drinkers. No hay supplementation was given.

In the experiment the same N doe was inseminated alternately with N or F1 semen, while the same F1 female was inseminated with N, F1 or A sperm after parturition. In this way, one doe could belong to two or three groups (NxN, F1xN or NxF1, F1xF1 and AxF1). Lactating does were inseminated 25 to 30 days *post partum*, while those which remained open (on the basis of pregnancy check by palpation 10 to 14 days after AI) were inseminated 28 to 30 days after the previous insemination. The long-wool angoras were shorn during the week prior to AI. Semen quality was evaluated microscopically for density and motility, and the fresh ejaculate found to be suitable for AI was diluted in a ratio of 1:5 to 8. Ovulation was induced by means of 1.5 µg GnRH analogue hormone (Ovurelin, Reanal) at the time of AI. Where larger litters were produced (N and F1 does: 10, A: over 6) within- group fostering was arranged. The does were free to nurse at any time. The kits were sexed, measured and tattooed individually at 21 days of age. Offspring were weaned at six weeks of age by moving the doe into another cage.

Statistical evaluation of the data was performed according to the GLM (General Linear Models) procedure with SAS software, version 6.09. The tables include least square means (LSM) and residual standard deviation (RSD). Levels of significance of the frequency distributions were determined by chi-square test (FREQ analysis, SAS version 6.09). The model used in the analysis of variance for testing the factors affecting each trait (litter size and litter weight) based on individual data, with consideration for the fixed effects (parity and season), was the following (with interpretation according to each individual trait):

Y_{ijklmn}= $\mu+Gd_i+Gs_j+Go_k+P_l+S_m+e_{ijklmn}$

where
- Y_{ijklmn} value observed
- μ overall mean
- Gd_i effect of maternal genotype (i=N, F1, A)
- Gs_j effect of paternal genotype (j=N, F1, A)
- Go_k genotype of progeny (k=NN, F1N, NF1, F1F1, AF1, AA)
- P_l effect of parity (l=1, 2, 3, 4, 5)
- S_m effect of season (m=spring, summer, autumn, winter)
- e_{ijklmn} random error

Does remaining open after three consecutive inseminations and those producing no litters before culling or death were excluded from the trial without replacement, and their data were eliminated from the evaluation.

RESULTS AND DISCUSSION

The adult weight of N, F1 and A rabbits differed significantly (P<0.001) in both sexes (female: 4404, 4097, 3381 g; male: 4866, 4040, 3369 g, respectively); compared to the N genotype, those of F1 were 7 to 17% and the angoras 23 to 31% smaller. The semen of the N bucks was found to contain more (P<0.001) live and intact sperm cells (87 and 84%) than that of the A males (76 and 69%), confirming that angora semen is of poorer quality than that originating from normal-haired rabbits (HU *et al*., 1988; THEAU-CLÉMENT *et al*., 1991).

During the experimental period the total loss of A does resulting from culling, death or exclusion was non-significantly 10% higher than for the other two genotypes (Table 2). Fifty two percent of A females produced only one litter (P<0.05), whereas the ratio of does producing 4 to 5 litters was the highest in the F1 genotype. During the period of the investigation the average number of kindlings per doe was similar in the N and F1 genotypes (2.8), while angora females produced non-significantly one litter fewer (1.8). These results concur with the weaker viability of angora does.

Table 2: Culling rate and distribution of rabbit does according to number of kindlings

	Doe genotype					
	N		**F1**		**A**	
n	51		65		31	
	n	%	n	%	n	%
Culling rate	31	60.8	41	63.1	23	74.2
No. of kindlings						
1	6	14.6[a]	14	23.0[a]	13	52.0[b]
2	13	31.7	15	24.6	6	24.0
3	10	24.4	10	16.4	4	16.0
4-5	12	29.3[ab]	22	36.1[a]	2	8.0[b]
Avg. kindlings/doe		2.76		2.77		1.80

a, b: P<0.05

Kindling rate was the highest in the F1xF1 group (89%) but the superiority of this group was only significant over the F1xN and AxA mating. The 10% better fertility of F1 rabbits compared to the other two genotypes indicates heterosis (Table 3). In comparison to N semen, that of the F1 and A bucks non-significantly decreased the kindling rate by 1% and 3%, respectively. In N and F1 does litter size at birth and at 21 days of age proved equal but

greater (P<0.05) than with the A females. Insemination with N, F1 or A semen had no impact on birth litter size. Litter size at birth is, therefore, primarily dependent on the genotype of the dam (BLASCO *et al*., 1993). Litter size at weaning decreased in the sequence of N, F1 and A females (Table 3), and by this time the detrimental effect of the F1 and A sire genotypes had become significant. DAMME *et al*. (1985) found no significant difference in birth litter size of purebred NZW and German angora x (German angora x NZW) groups, although the F1 does produced more populous litters (9.4 and 10.5). SHEN (1992) observed greater birth litter size in (NZW x German angora) x angora mating than in groups of purebred German or French angoras (6.0 to 7.6 and 8.2 to 10.2).

The viability of embryos and foetuses of different genotypes may have an influence on litter size. For this reason, the phenotypic ratios of normal-haired to angora progeny born from F1xF1 and AxF1 mating were also determined. This evaluation was carried out at three weeks of age, when the normal and angora phenotype can be distinguished. In contrast to the expected ratios, based on theory, of 3:1 for the F1xF1 group and 1:1 for the AxF1 mating, the proportion of normal-haired offspring proved to be 80% (P<0.05) in the first and 60% (P<0.001) in the second mating combination. In our previous study (EIBEN *et al*., 1996b) it was established that suckling mortality is independent on genotype (NN, AN, NA, AA), so an evaluation at three weeks of age did not affect the ratios determined. The fact that the occurrence of angora progeny was lower in both groups gives clear evidence of the poorer intrauterine viability of the AA genotype and also explains the smaller birth litter size noticed in the AxF1 group. In addition, this finding emphasises that the prenatal vitality of angora rabbits is weaker than that of their crossbred or NN littermates, not only in angora does (EIBEN *et al*., 1996a; EIBEN *et al*., 1999), but even in F1 females. One reason for the poorer survival ability of angora foetuses could be the pleiotropic effect of the angora gene (BOLET *et al*., 1996).

Table 3: Kindling rate, litter size, litter weight and mortality rate in different mating combinations of normal-haired (N), angora (A) and single-cross (F1) rabbits

		Kindling	Litter size				Litter weight		Mortality, %		
		rate, %	Total	Alive	d 21	d 42	Birth	d 21	wk 0-3 total	wk 0-3 suckling	wk 3-6
Group	NxN	75.9^{ab}	8.95^{a}	8.44^{a}	7.54^{ab}	7.21^{a}	497^{a}	2801^{a}	13.0^{a}	10.7^{a}	4.69^{ab}
sire x dam	F1xN	64.0^{a}	9.35^{a}	8.70^{a}	7.56^{ab}	7.30^{a}	500^{a}	2802^{a}	13.7^{a}	14.8^{ab}	3.75^{a}
	NxF1	75.4^{ab}	8.76^{a}	8.26^{a}	7.87^{a}	7.32^{a}	488^{a}	2671^{a}	10.9^{a}	11.6^{a}	6.40^{ab}
	F1xF1	89.2^{b}	8.70^{a}	8.78^{a}	7.09^{b}	6.52^{ab}	478^{a}	2359^{b}	6.00^{a}	20.9^{b}	7.13^{b}
	AxF1	75.3^{ab}	8.38^{a}	7.87^{a}	7.09^{ab}	5.79^{b}	466^{a}	2205^{b}	14.6^{a}	16.4^{ab}	14.6^{c}
	AxA	69.2^{a}	6.01^{b}	5.45^{b}	4.36^{c}	3.81^{c}	298^{b}	1218^{c}	40.5^{b}	15.6^{ab}	7.81^{b}
Dam	N	69.7^{a}	9.15^{a}	8.57^{a}	7.55^{a}	7.26^{a}	499^{a}	2801^{a}	13.3^{a}	12.8^{a}	4.22^{a}
	F1	79.7^{b}	8.62^{a}	8.30^{a}	7.35^{a}	6.54^{b}	477^{a}	2412^{b}	10.4^{a}	16.4^{b}	9.26^{b}
	A	69.2^{ab}	6.01^{b}	5.45^{b}	4.36^{b}	3.81^{c}	298^{b}	1218^{c}	40.5^{b}	15.6^{b}	7.81^{b}
Sire		NS	NS	NS	NS	**	NS	*	**	***	***
Parity		-	*	*	NS	*	**	**	**	NS	NS
Season		**	NS	NS	*	*	*	**	***	NS	NS
RSD		-	2.85	2.98	1.83	1.96	149	633	-	-	-

Means in the same column not bearing a common superscript differ (NS:P>0.05 *P<0.05 **P<0.01 **P<0.001)

Birth litter weight was lower in the AxA group (298 g) and higher with N and F1 does (499 g and 477 g, respectively). On calculation of the average individual birth weight of the kits similar values were recorded in the NxN, NxF1 and AxF1 groups (59 g), while lower weights

were observed for the mating of F1xN (57 g), F1xF1 (54 g) and AxA (55 g). Not only litter size but also birth litter weight was the lowest in the AxA group, evidently indicating the poorer intrauterine rearing ability of the angora breed. DAMME *et al*. (1985) also found no significant difference in birth weight among progeny born in NxN, AxN and AxF1 groups (52, 50 and 49 g, respectively). Comparing F1xA and purebred German or French angora groups, SHEN (1992) reported lower (50 to 52 g) and in the latter case higher (53 to 58 g) birth weight in connection with differences in birth litter size (8.2 to 10.2 vs. 6.0 to 7.6).

21-day litter weight was significantly lower by 14% in the case of F1 does and by 57% in A females, compared to N rabbits (Table 3). The explanation for this could be that F1 does have lower adult weight than N females, which is probably why they produce less milk. This hypothesis is corroborated by the near similar 21-day litter size (7.6 and 7.4) but significantly different 21-day litter weight (2801 g vs. 2412 g) of N and F1 females. Also, despite the same litter size and offspring genotype in the F1xN and NxF1 groups, the 21-day litter weight for the F1 does was lower (Table 3).

Total litter loss was 10% in the F1 does and 13% with the N females, but three times higher in the case of the A rabbits (41%; $P<0.01$). SZENDRŐ and BARNA (1984) emphasise that primarily the dam is responsible for the occurrence of total litter loss; thus, these data provide further evidence of the poorer nursing ability of angora females. Between 0 and 21 days of age the mortality rate was the same in the litters of the F1 and A does (16%), but significantly ($P<0.05$) lower with the N females (13%). The high mortality (21%) recorded in the F1xF1 group may be related to the larger birth litter size (8.78) and lower birth weight (54 g) of the kits. Suckling mortality between 21 and 42 days of age was 4% in the litters reared by the N females but twice as high ($P<0.01$) among the kits of the F1 and A does (9% and 8%, respectively).

CONCLUSIONS

As demonstrated by the data for losses recorded in this study, angora does are more sensitive to diseases and have poor vitality. In connection with this and their lower fertility, half of the angora females had only one parturition and their average number of kindlings per doe was also the lowest.

Pregnancy rate, litter size at birth and 21 days, litter weight and rate of total litter loss are determined mainly by the maternal genotype. F1 does produced smaller litters in size when inseminated with A semen. This is attributable to the poorer quality of A semen.

The angora gene is detrimental to intrauterine survival ability, as indicated by the higher phenotypic ratio (4:1) of normal-haired offspring vs. angoras observed in the F1xF1 group (expected 3:1), and also by the 1.5:1 distribution recorded as opposed to the theoretical proportion of 1:1 in favour of normal-haired progeny in the AxF1 mating.

Due to a heterosis effect, F1 does showed better fertility as compared to N females. The beneficial influence of heterosis could also be observed in intrauterine and postnatal rearing ability, as litter size and individual and litter weight at birth for the F1 does were comparable to the values recorded for the N females.

Acknowledgements

This research was supported by the National Scientific Research Fund (OTKA, T-016168).

This paper was prepared in the framework of the Hungarian-French Intergovernmental Scientific and Technological Cooperation Programme, within a research project supported by the Hungarian National Committee for Technical Development (OMFB) and its French partner, the Ministry of Foreign Affairs (Le Ministère des Affaires Etrangères).

E-mail address of the corresponding author: eiben@sunserv.katki.hu

REFERENCES

BLASCO A., BINADEL J. P., BOLET G., HALEY C. S., SANTACREU M. A., 1993. The genetics of prenatal survival of pigs and rabbits: a review. *Livestock Prod. Sci.*, 37. 1-21.

BOLET G., THEAU-CLÉMENT M., THÉBAULT R.G., ROCHAMBEAU H. de, VRILLON J.L., 1996. Effects of daylength, age at mating and reproduction way on reproductive performances of French Angora rabbits. *Proc. 6th World Rabbit Congress, Toulouse*, Vol. 1. 325-331.

DAMME K.. ROTTMANN O.. ANTES R.. SAGSTETTER F. X.. 1985. Produktionsmerkmale von Neuseeland und Angora Kaninchen und deren Kreuzungen. *Züchtungskunde* 57. (3). 197-206.

EIBEN CS., SZENDRŐ ZS., ALLAIN D., THÉBAULT R.G., RADNAI I., BIRÓNÉ NÉMETH E., LANSZKI J., 1996a. Study on the performance of normal hair, Angora and their reciprocal crossbred rabbits: 1. Components of litter size. *Proc. 6th World Rabbit Congress, Toulouse*, Vol. 1. 339-343.

EIBEN CS.. SZENDRŐ ZS.. ALLAIN D.. THÉBAULT R.G.. RADNAI I.. BIRÓNÉ NÉMETH E.. LANSZKI J.. 1996b. Study on the performance of normal hair. Angora and their reciprocal crossbred rabbits: 2. Reproduction traits. *Proc. 6th World Rabbit Congress. Toulouse*. Vol. 1. 345-350.

EIBEN CS.. SZENDRŐ ZS.. ALLAIN D.. THÉBAULT R.G.. RADNAI I.. BIRÓNÉ NÉMETH E.. LANSZKI J.. 1997. Impact of the coat length on the performance of Angora doe rabbits. *Proc. 10th Symposium on Housing and Diseases of Rabbits. Furbearing and Pet Animals. Celle.* 39-49.

EIBEN CS.. SZENDRŐ ZS.. ALLAIN D.. THÉBAULT R.G.. RADNAI I.. BIRÓNÉ NÉMETH E.. LANSZKI J.. 1999. The performance of Angora rabbit does and their progeny depending on the semen used for Artificial Insemination. *World Rabbit Science*. Vol. 7. (1). 3-8.

HU J. F.. HONG Z. Y.. LENG H. R.. WANG Q. X.. 1988. The variabilities in the quality of semen of German Angora and China Angora in summer and autumn. *Proc. 4th World Rabbit Congress. Budapest.* Vol. 2. 524.

ROCHAMBEAU H. de. 1988. Genetics of the rabbit for wool and meat production. *Proc. 4th World Rabbit Congress. Budapest.* Vol. 2. 1-68.

SAS. 1993. Version 6.09. SAS. Inst. Inc. Cary. NC. USA

SHEN Y. Z.. 1992. Efficiency analysis of the coarse-wool hybrid rabbits. *J. Appl. Rabbit Res.*. 15. 1680-1688.

SZENDRŐ Zs., BARNA J., 1984. Some factors affecting mortality of suckling and growing rabbits. *Proc. 3rd World Rabbit Congress, Rome*, 166-173.

THEAU -CLÉMENT M.. THÉBAULT R. G.. BOLET G.. ROCHAMBEAU H. de. 1991. Reproduction of a French strain of Angora rabbits: ovulation rate of females and semen production of males. *Reprod. Nutr. Dévelop.*. 31. 6. 667-673.