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Genetics and production traits in the Spanish Common rabbit breed: relations between markers and different production traits

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SUMMARY - Two specific proteins as transferrin and hemoglobin are considered in this work. Blood samples of 330 Spanish Common females at two physiological stages (28 days of gestation and 24 hours post-parturition) were analysed by PAGE. The majority of females presented Tf patterns with Low Fe contents (determined by atomic absorption) at the end of gestation. The addition of iron to feed results in an increase of the degree of the Tf molecules saturation, even at late gestation (28 days). However, no differences were observed when females were studied at 24 hours post-parturition. The effect of the addition of iron to feed on production traits was estimated using the method of Harvey (1977). When the rich feed is given to females and young rabbits during lactation, a beneficial effect is observed on many production traits. Hemoglobin was studied by electrophoresis, using samples from 107 Spanish Wild rabbits, and 124 Spanish Common rabbits. Only one allele (Hb^1) was observed in the Spanish Common breed, whereas the Spanish Wild rabbit showed two alleles. Oxygen binding studies revealed the existence of differences between breeds for the capacity of oxygen binding by Hb molecules. No differences between Hb phenotypes were observed.

Key words: Transferrin, hemoglobin, production traits, Spanish Wild rabbits, Spanish Common rabbits.

RESUME - "Caractères génétiques et productifs de la race Espagnole de lapin commun : relations entre marqueurs et différents caractères de production". Dans ce travail on a étudié deux protéines : la transferrine et l'hémoglobine. 330 échantillons sanguins de lapines de la race Commune Espagnole ont été analysés par electrophorèse en gel de polyacrylamide. Les femelles présentaient deux états physiologiques différents : à 28 jours de gestation et vingt-quatre heures après la mise bas. La plupart des femelles ont présenté des types de Tf avec une petite quantité de fer (determiné par absorption atomique) à la fin de la gestation. En ajoutant du fer à l'aliment on obtient une augmentation du degré de saturation des molécules de Tf, effet qu'on constate à la fin de la gestation (28 jours). Mais on n'a pas observé de différences chez les femelles 24 heures après la mise bas. On a ajouté du fer à l'aliment, et on a estimé les caractères productifs en utilisant la méthode HARVEY (1977). Quand les femelles et les lapereaux ont été nourris avec un aliment riche en fer pendant la lactation, nous avons observé un effect positif pour plusieurs paramètres productifs. On a étudié l'hémoglobine par électrophorèse en gel d'amidon en utilisant des échantillons de 107 lapins Sauvages Espagnols et 124 de la race Commune Espagnole. Chez les lapins de la race commune un seul allèle a été observé cependant que la race sauvage montre 2 allèles. On a aussi fait des études sur le transport d'oxygène. Ces études démontrent l'existence d'une différence entre races pour la capacité de transport d'oxygène des molécules d'hémoglobine. On n'a pas trouvé de différences entre phénotypes d'hémoglobine.

Mots clés: *Transferrine, hémoglobine, paramètres productifs, lapin Sauvage Espagnol, lapin Commun Espagnol.*

Introduction

For many years, geneticists have aimed their efforts at elucidating the influence of protein genetic variation and breed differences on physiological performance in man (SEZAKI, 1973; SWAIN *et al.*, 1980) and on production traits in animal species such as cattle (GRANADO and BENOVIDES, 1979; OSTERHOFF *et al.*, 1970; MANDAL and DATTAGUPTA, 1985), sheep (RASMUSSEN and TUCKER, 1973; GOOTWINE, 1988), etc...

In this work two specific proteins as transferrin and hemoglobin are considered.

Electrophoretically detected genetic variants of Tf and Hb molecules have been found in many species (MANWELL and BAKER, 1970; ARANA *et al.*, 1987; GOOTWINE, 1988).

In rabbits, there is evidence for the existence of genetic variation in some breeds, for example Spanish Wild rabbit (ZARAGOZA *et al.*, 1987; ARANA *et al.*, 1987; FERRAND *et al.*, 1988).

The transferrin is related with iron, a very important mineral in animal feed.

In this work, the effect of the addition of iron to feed on production traits was studied. Also, a study was made on the influence of the addition of iron to feed on the degree of saturation of the Tf molecule in different physicological stages of females and the relationship between Tf electrophoretic patterns (in pregnancy and paturition) and production traits.

Likewise, the hemoglobin is a protein involved in respiration. A possible relationship between genetic variants, and their affinity for oxygen (O_2) has been searched in some rabbit breeds.

Material and methods

A total of 1189 individuals (165 litters) and 330 blood samples from female rabbits of the Spanish Common breed were analyzed for the study of Tf and the production traits. The 165 litters were obtained mating 19 sires with 74 dams.

The animals were placed in galvanized flat deck cages, under natural ventilation.

A semi-intensive rhythm of reproduction was used, the weaning age was 30 days and the slaughter age was 10-11 weeks (when the majority of animals had reached 2 Kg.)

Two feed types were used: type I or experimental (rich in Fe, 1600 ppm Fe) and type 2 or commercial (regular Fe, 600 ppm Fe). The effect of the feed type was studied in two different periods: a) when the feed was consumed by dams and young rabbits during lactation and b) when the feed was consumed by the young rabbits during post-weaning period.

In order to evaluate the effect of the feed type on the production traits, the dams were distributed at random in two lots.

	LOTS	
	Lot 1	Lot 2
Feed type	1	2
N.° of litters	81	84

Also, at the post-weaning period, the litters were distributed at random in four lots.

	LOTS			
	Lot 1	Lot 2	Lot 3	Lot 4
Feed type	1	1	2	2
Feed type at postweaning	1	2	1	2
N.° of litters	36	35	33	33

The electrophoretic patterns of Tf were analysed in the females at two physiological stages: 28 days of gestation and 24 h. post-parturition. Electrophoretic variations of Tf were detected by PAGE (ZARAGOZA, 1984).

For the study of Hb, 231 blood samples were analyzed, obtained from 107 Spanish Wild rabbits and 124 Spanish Common rabbits. For oxygen binding studies of Hb, additional samples were obtained from 44 of these animals. This affinity was indirectly estimated by quantifying the concentration of 2,3 diphosphoglycerate referred to a mililiter of either blood or erythrocytes, knowing that both concentrations are inversely proportional to the capacity of Hb binding oxygen (BAUER, 1983).

All differences were estimated using the method II of HARVEY (1977). A correction for the systematic effects of season and parity was applied considering both effects as fixed. The model used was:

$$Y_{ijklmn\tilde{n}} = u + s_i + e_j + p_k + Tf\ 28_l + Tf\ pp_m + pm_n + pc_{\tilde{n}} + (ep)_{jk} + (p\ Tf\ 28)_{kl} + (p\ Tf\ pp)_{kn} + e_{ijklmn\tilde{n}}$$

Where:

$Y_{ijklmn\tilde{n}}$ = each value of the dependent variable

u = mean

s_i = sire effect

e_j = season effect

p_k = parturition number effect

$Tf\ 28_l$ = Effect of Tf-l pattern at 28 days of gestation

$Tf\ pp_m$ = Effect of Tf-l pattern at 24 h. post-parturition

pm_n = Effect of feed type consumed at lactation

$pc_{\tilde{n}}$ = Effect of feed type consumed at post-weaning period

$(ep)_{jk}$, $(p\ Tf\ 28)_{kl}$, $(p\ Tf\ pp)_{km}$ = Interactions between the different effects

$e_{ijklmn\tilde{n}}$ = error effect

Results and discussion

RESPECT TO TF PROTEIN

— Iron contents in rabbit female plasma can be monitored by PAGE (ZARAGOZA *et al.*, 1987).

— The majority of females presented Tf patterns with low Fe contents (determined by atomic absorption) at the end of gestation.

— The need for iron in pregnant females is high (POLLICOVE, 1979), the use of high iron content feed results in an increase of iron in Tf molecules even at late gestation (28 days) (see table 1).

Table 1. Number and percentage of parturitions observed in each lot with respect to the different electrophoretic patterns of Tf-1 in 28 days pregnant rabbits.

Feed type	Electrophoretic patterns of Tf (according to Fe contents)				
	Low		Intermediate		High
	Pattern 1 obs. (exp.)	Pattern 2 obs. (exp.)	Pattern 3 obs. (exp.)	Pattern 4 obs. (exp.)	Patterns 5 and 6 obs. (exp.)
1 (High Fe)	10 (9,89)	29 (39,02) 48,77 %	13 (11,36)	19 (11,65) 39,03 %	10 (9,89) 12,20 %
2 (regular Fe)	10 (10,12)	49 (39,97) 70,24 %	10 (11,64)	5 (12,14) 17,86 %	10 (10,12) 11,90 %

In fact, an increase in the number of females with pattern Tf-1-4 at the expense of a decrease in the females with pattern Tf-1-2 was observed.

The differences between lots were significant (X^2 of contingency = 13.11; $p<0.05$). However, as table 2 shows, no differences between lots were observed when females were studied at 24 h. post-parturition (X^2 of contingency = 3.99, $p>0.05$). The majority of females in both lots showed the Tf-1-5 and Tf-1-6 patterns.

— When Fe rich feed is given to females and young rabbits during lactation, a beneficial effect is observed on many production traits.

Table 2. Number and percentage of parturitions observed in each lot with respect to the different electrophoretic patterns of Tf-1 in females at 24 horas post-parturition.

Feed type	Electrophoretic patterns of Tf (according to Fe contents)					
	Low	Intermediate		High		
	Pattern 1 and 2 obs. (exp.)	Pattern 3 obs. (exp.)	Pattern 4 obs. (exp.)	Patterns 5 obs. (exp.)	Pattern 6 obs. (exp.)	
1 (High Fe)	2 (2,47) 2, 44 %	3 (5,43) 14, 63 %	8 (6, 92)	4 (4,94) 82, 93 %	64 (62,24)	
2 (Regular Fe)	3 (2,53) 3,57 %	8 (5,57) 15, 48 %	5 (7,08)	6 (5,06) 80,95 %	62 (63,76)	

As table 3 shows, the feed type 1 (high Fe contents) was beneficial with respect to feed type 2. The consumption of feed type 1 resulted in:

* Higher litter size.

* Higher litter weight in different periods.

* Lower individual average weight. This fact was expected, given the negative correlation existing between litter size (or weight) and individual average weight (RODELLAR *et al.*, 1990).

* Lower mortality in different periods (ASHMEAD, 1979; MOZOROVA, 1981; WILLIAMS, 1982).

— Only the feed consumption 45 days and mortality 45 days-slaughter were significant to post-weaning young rabbits (see table 4).

— The effect of Fe feedstuffs is much more powerful when this feed is consumed by females and young rabbits during lactation, rather than by post-weaning young rabbits.

No significant interaction was obtained between type of feedstuff consumed in both stages (lactation and post-weaning periods) for any of the traits (data not shown).

— A relationship is observed between Tf patterns (reflecting plasma Fe concentrations) of females 28

Table 3. Quantification of the effect of the feed type given to females and young during lactation

Trait	Feed 1 - Feed 2
Numerical traits	
Total Born	+ 1,96 (± 0,84)
Born alive	+ 1,34 (± 1,04)
Litter size at 21 days	+ 1,18 (± 1,00)
Litter size at weaning	+ 2,54 (± 0,84)
Litter size at 45 days	+ 2,86 (± 0,86)
Litter size at slaugther	+ 2,76 (± 0,88)
Weight traits	
Litter weight at birth	+ 141.20 (±52, 40)
Litter weight at 21 days	+ 629,28 (±326, 98)
Litter weight at weaning	+2.064,00 (±726, 52)
Average weight at birth	-10,10 (±4,74)
Average weight at 21 days	-145,68 (±48,10)
Average weight at weaning	-111,90 (±54,50)
A. D. G. * birth-21 days	4,56 (±1,56)
Feed consumption to 45 days	+3220,34 (±1070, 66)
Mortality traits	
Mortality birth-weaning	-12,58 (±6,68)
Mortality weaning-45 days	-4,68 (±3,92)

* A. D. G. = Average daily gain

Table 4. Quantification of the effect of the feed type given to postweaning young rabbits.

Trait	Feed 1 - Feed 2
Feed consumption 45 days	+ 946,00 (± 457, 26)
Mortality 45 days-slaughter	-5,76 (± 2,58)

days of gestation (but not at 24 h. post-parturition) and production traits:

* The most positive effect was observed for patterns No. 5 (Tf-1-5); containing many Tf molecules with two and few molecules with one Fe atom.

* Clearly, pattern No. 6 (Tf-1-6; corresponds to almost 100% Fe saturated Tf molecules) is detrimental (See Table 5).

Table 5. Quantification of the effect of the transferrin (Tf-1) patterns of females at 28 days of gestation on production traits.

	Electrophoretic pattern					
Trait	1	2	3	4	5	6
Numerical traits						
litter size weaning	-0,57 (±0,59)	+0,25 (±0,36)	+0,20 (±0,50)	+0,54 (±0,20)	+1,56 (±0,70)	-2,02 (±0,59)
litter size 45 days	-0,35 (±0,37)	-0,10 (±0,51)	+0,66 (±0,61)	+0,62 (±0,53)	+1,08 (±0,53)	-1,89 (–0,60)
litter size slaughter	-0,35 (±0,38)	-0,16 (±0,53)	+0,49 (±0,62)	+0,73 (±0,54)	+1,38 (±0,64)	-2,09 (±0,61)
Weight traits						
litter weight weaning	-218,23 (±231,33)	+73,34 (±195,02)	+179,39 (±140,05)	+826,78 (±451,17)	+500,48 (±351,24)	-831,23 (±228,05)
litter weight 45 d.	-336,77 (±314,06)	-172,34 (±432,72)	+346,20 (±515,29)	+826,78 (±401,17)	+995,70 (±681,21)	-1759,10 (±507,23)
I. D. G. birth-weaning	-0,19 (±1,22)	-1,22 (±0,74)	+0,56 (±1,03)	-0,90 (+1,06)	-2,20 (±1,86)	+3,97 (±1,20)
Feed consumption 45 d	-69,43 (±432,83)	-220,91 (±637,69)	+795,23 (±759,37)	+592,06 (±664,87)	+1727,41 (+1151,25)	-2824 (+747,49)

RESPECT TO HB PROTEIN

— Only one allele (Hb^1) was observed in the majority of breeds (SC, LB, B, C, NZ), whereas the Spanish Wild rabbit showed two alleles, at a frequency of 0.81 (Hb^1) and 0.19 (Hb^2). The population was at Hardy-Weinberg equilibrium for the Hb locus.

— The results show that under the experimental conditions applied, there are significant differences (F=12,06 for 2,3 DPG/ml.blood and F=5,97 for 2,3 DPG/ml. erythrocytes) between breeds for the oxygen binding capacity by Hb molecules (lower in wild rabbits compared to Spanish Common). Different results were obtained in ovine (KHATTAB *et al.*, 1964).

— The differences between Hb phenotypes on oxygen fixation were non significant.

A possible explanation for the lack of differences between variants would be that the site of the Hb molecule, responsible for the electrophoretic variation, may not affect the oxygen binding. Alternatively, it may be possible that this site does affect oxygen binding, but in a subtle rather than a strong way. If this were the case, a substantially higher number of wild rabbits should be analysed to detect significance (especially knowing that the frequency of the Hb^2 allele is low among these rabbits). Finally, it is possible that differences between variants are magnified when directly measuring the oxygen binding capacity rather than using the indirect but readily available 2,3 DPG method.

In any case, whether the observed differences between breeds have a genetic explanation is unknown. Considering the different nature of the environment associated with these breeds, it is conceivable that the environment may play an important role, in addition to or in the place of genetic factors: the greater muscular activity carried out by wild rabbits compared to common rabbits could "to the right", no that for lower oxygen pressures the Hb molecule would liberate this gas earlier. Molecular and heritability studies could help elucidating the relative role of the genetic vs. environmental factors on the observed breed differences.

References

ARANA, A., ZARAGOZA, P., RODELLAR, C. and AMORENA, B. (1987): Evidence for transferrin polymorphism in Spanish Wild rabbits. Animal Genetics, 18, 125-132.

ASHMEAD, D. (1979): The influence of chelated iron proteinate, fed to sows with no iron supplementation, to their body weight. Journal of Animal Science, 49, Sup. 1, 235.

BAUER, J.D. (1983): Investigación de laboratorio en la hemoglobina. En: Sonnenwirth, A.C. y Jarett, L. (Eds). Métodos y Diagnósticos del Laboratorio Clínico. Edit. Medica Panamerica, 8ª Edición, pp. 742-847. Buenos Aires.

FERRAND, N., CARVACHO, G. and AMURIN, A. (1988): Transferrin (Tf) polymorphism in wild rabbit, *Oryctolagus cuniculus*. Animal Genetics, 19, 295-300.

GOOTWINE, E. (1988): Haemoglobine type frequencies in the Assaf (Awassi and East Friesian) dairy sheep 20 years after its formation. Génétique, Sélection et Evolution, 20:99-104.

GRANADO, A. and BENOVIDES, V. (1979): Serum albumin variants and reproductive characters in Zebu and F1 crosses (HL x Zebu). Revista de Salud Animal, 1: 105-112.

HARVEY, D.G. (1977): Mixed model least-squared and maximum likelihood computer program. Dairy Science Dept. The Ohio State Univ., Columbus, Ohio 43210. Modified by Animal Science Dept., PURDUE Univ.

KHATTAB, A.G.H., WATSON, J.H. and AXFORD, R.F. (1964): Inherited physiological differences in red cell characteristics of Welsh mountain sheep. Journal of Agricultural Science, 63:173-175.

MANWELL, C. and BAKER, M.A. (1970): Molecular Biology and the Origin of Species: Heterosis, Protein Polymorphism and Animal Breeding. Sidgwick and Jackson London.

MANDAL, B.K. and DATTAGUPTA, R. (1985): Serum albumin polymorphism and its relationship to economic traits in crossbred cattle. Anim. Blood Grps. Biochem. Genet. 16: 229-233.

MOROZOVA, K.N. (1981): Survival and growth of rabbits given mixed feeds with different amounts of iron and copper. Zwerovodstva i Krolikobofdtva, 23, 73-80.

OSTERHOFF, D.R., KASSIER, H.G. and WARD-COX, I.S. (1970): Serum transferrin types in healthy merino rams and in those affected with epididymitis. J.S.A. Fr. Vet. Med. Ass., 41:329-333.

POLLICOVE, M. (1978): The metabolic basis of inherited disease. In: Hemocromatosis. STCUBURY, J.B., VINGAARDEN, J.B. and FREDICKSON, D.S. (Eds.). 4 ed. McGrawhill. New York.

RASMUSEN, B.A. and TUCKER, E.M. (1973): Transferrin types and reproduction in sheep. Anim. Blood Grps Biochem. Genet. 4: 207-220.

RODELLAR, C., ZARAGOZA, P., OSTA, R., ZARAZAGA, I. and AMORENA, B. (1990): Phenotypic and genetic correlations between production traits in the Spanish Common rabbit breed. Génétique, Sélection, Evolution (Submitted for publication).

SEZAKY, T. (1973): The haptoglobin level and types in haemotological diseases. J. Jap. J. Clin. Haematol. 14: 495-501.

SWAIN, B.K., TALUKDER, G. and SARMA, A. (1980): Genetic variation in serum proteins in relation to disease. Medical Biology, 58: 246-263.

WILLIAMS, J. (1982): The evolution of transferrin. Trends in Biochemical Sciences, 394-397.

ZARAGOZA, P. (1984): Polimorfismos bioquímicos sanguíneos en conejos (*Oryctolagus cuniculus* L.) explotados en España: Estudios electroforéticos y poblacionales. Doctoral Thesis. Universidad de Zaragoza.

ZARAGOZA, P., ARANA, A. and AMORENA, B. (1987): Relationship between rabbit transferrin electrophoretic patterns and plasma iron concentrations. Animal Genetics. 18:51-62.