SEGREGATION ANALYSIS OF COAT COLOUR PHENOTYPES IN LLAMA

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INTRODUCTION

Llama (*Llama glama L.)* fibre is especially appreciated because of the high quality of undercoat and because of the large number of natural colours (Frank *et al*., 1985 ; Delgado *et al*., 2001 ; Ayala, 2001 ; Ayala *et al*., 2001 ; Quispe *et al*., 2001). Coat colour of llama has been classified by several authors (for a review see Renieri, 1996). In order to establish correct reproductive practices to uniform pigmentary patterns, E.C. INCO Programme SUPREME funded a plan of segregation analysis on Argentinian llamas. The phenotypes involved on the experimental plan are : pheomelanic with eumelanic extremities (PEE), wild (W) and eumelanic black (EB). PEE is a pheomelanic (red or light brown) phenotype with deeply eumelanic extremities ; W is light fawn phenotype with a white zone extension out of the belly, little black hair on head and limb extremities ; EB is an entirely eumelanic black phenotype (Frank, 1995).

MATERIALS AND METHODS.

Phenotypic segregations. The phenotypic segregations analyzed and the crossing adopted are : PEE *vs.* W (PEE x PEE, PEE x W, W x W) and PEE *vs* EB (PEE x PEE, PEE x EB, EB x EB). The genetic hypothesis concerned are respectively : 3 PEE : 1 W, 1 PEE : 1 W, 0 PEE : 1 W, for PEE *vs.* W and 3 PEE : 1 EB, 1 PEE : 1 EB, 0 PEE : 1 EB, for PEE *vs.* EB.

Statistical procedures. Only the families containing at least one individual presenting the "proband" phenotype have been included (Huston *et al*., 1974). The expected frequencies for each family have been corrected using the method proposed by Andersen (Bernstein, 1929 ; Andersen, 1974 a, b). A X^2 test with Yates correction for continuity has been used for testing the goodness of fit between the observed and the expected frequencies. Sex ratio at birth for each segregation has been tested using a X^2 test with Yates correction for continuity.

RESULTS AND DISCUSSION.

Segregation between pheomelanic with eumelanic extremities (PEE) and wild (W) animals. Table 1 presents the results of segregation among PEE animals in half-sib families with at least one proband. *A priori* 3 : 1 expectation of dominance of PEE on W phenotype has been tested. The observed *ratio* of PEE to W animals agrees well with the expected *ratio* (X^2 =

0.2007853 ; 1 df ; 0.50 < P < 0.75). The observed sex-*ratio* at birth agrees well with the expected *ratio* (X^2 = 0.6538492 ; 1 df ; 0.25 < P < 0.50).

Table 1. The results of segregations among pheomelanic with eumelanic extremities (PEE) animals in the families with at least one proband wild

Paternal half-sib family	Family size	Observed frequencies				Expected frequencies (corrected)	
		N° of dominants (PEE)		N° of recessives (W)		d	r
		F	M	F	M		
135	8	2	3	1	2	5.778	2.222
203	3	1	1	1	0	1.703	1.297
2038	4	1	1	2	0	2.537	1.463
3021	11	5	3	2	1	8.129	2.871
Total		9	8	6	3		
Total	26	17		9		18.147	7.853

d = dominant phenotype; r = recessive phenotype; F = females; M = males.

The results of segregation between PEE and W animals are presented on table 2. *A priori,* 1 : 1 expectation of dominance of PEE on W phenotype has been tested. The observed *ratio* of PEE to W animals agrees with the expected *ratio* (X^2 = 2.3661978 ; 1 df ; 0.10 < P < 0.25). The observed sex-*ratio* at birth agrees with the expected *ratio* with a high value of X^2 (2.9545453 ; 1 df ; 0.05 < P < 0.10).
The crossing between 2 wild males and 4 wild females produced 4 wild animals.

Table 2. The results of segregations between pheomelanic with eumelanic extremities (PEE) and wild (W) animals

Paternal half-sib family	Family size	Observed frequencies				Expected frequencies Corrected	
		N° of dominants (PEE)		N° of recessives (W)		d	r
		F	M	F	M		
135	11	5	3	2	1	5.497	5.503
2038	6	1	2	3	0	2.952	3.048
5049	2	1	0	1	0	0.667	1.333
200 (SG)	3	1	1	1	0	1.286	1.714
Total		8	6	7	1		
Total	22	14		8		10.402	11.588

Segregation between pheomelanic with eumelanic extremities (PEE) and eumelanic black (EB) animals. Table 3 presents the results of segregation among PEE animals in half-sib families with at least one proband. *A priori* 3 : 1 expectation of dominance of PEE on EB has been tested. The observed *ratio* of PEE to EB animals agrees well with the expected *ratio* (X^2

= 0.4623161 ; 1 df ; 0.50 < P < 0.75). The observed sex-*ratio* at birth agrees with the expected *ratio* at birth (X^2 = 0.4166666 ; 1 df ; 0.50 < P < 0.75).

Table 3. The results of segregations among pheomelanic with eumelanic extremities (PEE) animals in half- sib families with at least one proband eumelanic black (EB)

Paternal half-sib family	Family size	Observed frequencies				Expected frequencies Corrected	
		N° of dominants (PEE)		N° of recessives (EB)		d	r
		F	M	F	M		
1001	3	1	1	1	0	1.703	1.297
5049	5	0	3	2	0	3.360	1.640
5112	4	3	0	0	1	2.537	1.463
Total		4	4	3	1		
Total	12	8		4		9.600	3.400

Table 4 presents the results of segregation between PEE and EB animals. *A priori* 1 : 1 expectation *ratio* of dominance of PEE has been tested. The observed *ratio* of PEE to EB animals agrees well with the expected *ratio* (X^2 = 0.0795277 ; 1df ; 0.75 < P < 0.90). Dominance of PEE is incomplete because one female in family 4076 presented a mule stripe pattern. The observed sex-*ratio* at birth agrees perfectly with the expected *ratio*.

Table 4. The results of segregations between pheomelanic with eumelanic extremities (PEE) and eumelanic black (EB) animals

Paternal half-sib family	Family size	Observed frequencies				Expected frequencies corrected	
		N° of dominants (PEE)		N° of recessives (EB)		d	r
		F	M	F	M		
138	8	2	1	2	3	3.984	4.016
4071	3	1	0	1	1	1.286	1.714
4076	8	2[A]	3	1	2	3.984	4.016
21422	6	2	1	1	2	2.952	3.048
21434	4	2	0	1	1	1.867	2.133
21086 (EB)	3	1	1	0	1	1.286	1.714
Total		10	6	6	10		
Total	32	16		16		15.359	16.641

[A] one mule stripe.

Table 5 presents the results of segregation among EB animals. All borns are EB. The observed sex-*ratio* at birth agrees well with the expected *ratio* (X^2 = 0.3703702 ; 1 df ; 0.50 < P < 0.75).

Table 5. The results of segregations among eumelanic black (EB) animals

Paternal half-sib family	Family size	N° of recessives	
		F	M
138	15	7	8
4076	5	2	3
21422	3	3	0
2052	4	0	4
Total		12	15
Total	27	27	

CONCLUSION

Monofactorial hypothesis of inheritance explains the relationship between PEE and W patterns. PEE is autosomal dominant on W. Monofactorial hypothesis of inheritance explains also the relationship between PEE and EB. PEE is autosomal dominant on EB. EB pattern is completely recessive.

In the first case the genetic hypothesis is the dominance of the A^Y on A^+ allele at the *Agouti* locus, while in the second is the dominance of the A^Y on A^s allele (recessive allele) at the *Agouti* locus.

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