SEGREGATION ANALYSIS OF IRREGULAR SPOTTING AND FULL WHITE IN LLAMA

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INTRODUCTION

Full white no albino is especially appreciated by textile industy. Spotting depreciates the quality of fibres (Sponenberg, 1990). Several biological mechanims for full white and spotting have been found in domestic mammals (Silvers, 1979).
In order to establish in llama correct reproductive practices for full white and without spotting, E.C. INCO Programme SUPREME funded a plan of segregation on Argentinian llamas.

MATERIALS AND METHODS

Phenotypic segregations. Two phenotypic segregations have been analysed : a) Self coloured (SC) *vs.* Irregular spotting (IS) and b) Full white (FW) *vs.* Self Coloured (SC). The crosses have been performed in 3 Argentinian commercial farms.
Statistical procedures. In the SC *vs.* IS segregation, only the families containing at least one "proband" have been included (Huston *et al*., 1974). The expected frequencies for each family have been corrected using the method proposed by Andersen (Andersen, 1974 a, b). A X^2 test with Yates correction for continuity has been used for testing the goodness of fit a) between observed and expected segregations, b) sex ratio at birth in SC x SC crossing.

RESULTS AND DISCUSSIONS

Segregation between self coloured (SC) and irregular spotted (IS) animals. In the the families containing at least one "proband" *a priori* 3 : 1 expectation *ratio* of dominance of self coloured on irregular spotting has been tested. The observed *ratio* of self coloured to spotted animals agrees well with the expected *ratio* (X^2 = 0.4656592 ; 1 df ; 0.25 < P < 0.50). The observed sex-*ratio* at birth agrees well with the expected *ratio* (X^2 = 0.1754385; 1 df ; 0.50 < P < 0.75). In the segregation, no full white (FW) animals have been observed.

Table 1. The results of segregations for matings among self coloured (SC) animals

Paternal half-sib families	Family size	Observed frequencies				Expected frequencies corrected	
		Self Coloured		Irregular Spotted		d	r
		F	M	F	M		
135	11	4	5	2	0	8.129	2.871
138	11	2	7	1	1	8.129	2.871
1001	4	1	2	1	0	2.537	1.463
3021	10	4	3	2	2	7.351	2.649
4076	12	4	6	1	1	8.902	3.098
5112	5	1	1	3	0	3.360	1.640
21086	4	1	2	0	1	2.537	1.463
Subtotal by sex		17	26	10	4		
Subtotal by phenotype	57	43		14		40.945	16.055
203	3	2	1	0	0	/	/
2038	4	3	1	0	0	/	/
2052	2	0	2	0	0	/	/
21155	3	0	3	0	0	/	/
23001	1	0	0	0	1	/	/
Total by sex		22	33	10	5		
Total by phenotype	70	55		15			

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

Table 2. The results of segregations for matings between self coloured (SC) and irregular spotted (IS) animals

Paternal half-sib families	Family size	Observed frequencies				Expected frequencies corrected	
		Self Coloured		Irregular Spotted		d	r
		F	M	F	M		
135	10	4	2	2	2	4.995	5.005
138	8	3	3	1	1	3.984	4.016
2038	7	3	1	1	2	3.472	3.528
2052	3	0	1	2	0	1.286	1.714
3021	6	1	2	2	1	2.952	3.048
4071	4	2	1	1	0	1.867	2.133
4076	6	1	4	0	1	2.952	3.048
5049	4	0	1	2	1	1.867	2.133
21011	3	1	1	1	0	1.286	1.714
21086	8	2	3	0	3	3.984	4.016
21155	3	1	1	1	0	1.286	1.714
21422	5	2	1	1	1	2.419	2.581
Total by sex		20	21	14	12		
Total by phenotype	67	41		26		32.35	34.65

A priori 1 : 1 expectation *ratio* of dominance of self coloured on irregular spotted has been tested. The observed *ratio* of self coloured to spotted animals disagrees with the expected *ratio* (X^2 = 4.4694795 ; 1 df ; $0.025 < P < 0.05$). In the family 21011 spotted born appears almost white.

Table 3. The results of segregation for matings among irregular spotted (IS) animals

Paternal half-sib families	Family size	Irregular spotted		Self coloured	
		F	M	F	M
4071	4	2	2	0	0
5049	7	2	1	0	4
21422	4	1	0	2	1
21434	2	1	1	0	0
Total by sex		6	4	2	5
Total by phenotype	17	10		7	

Both spotted and self coloured animals appear in the cross progeny. The presence of a self coloured progeny disagrees with the hypothesis of a recessive irregular spotting.

Segregation between full white (FW) and self coloured (SC) animals

Table 4. The results of segregations for matings between full white (FW) and self coloured (SC) animals

Paternal half-sib families	Maternal phenotype	Family size	Full white		Self coloured		Spotted	
			F	M	F	M	F	M
133	FW	4	1	0	0	0	0	3
	SC	32	2	4	1	5	7	13
136	FW	8	2	1	0	0	2	3
201	SC	5	0	0	0	0	2	3
202	FW	4	1	1	0	0	1	1
	SC	5	0	0	1	1	1	2
205	SC	14	1	0	1	1	6	5
30144	SC	2	0	0	1	1	0	0
30175	SC	2	0	0	0	1	0	1
30181	SC	1	0	0	0	1	0	0
31001	SC	4	1	0	1	0	0	2
31002	SC	2	0	0	0	0	2	0
5049	SC	1	0	0	1	0	0	0
21086	SC	1	0	0	0	0	1	0
Total by sex			8	6	5	11	22	33
Total by phenotype		85	14		16		55	

Segregation among white parents (FW x FW) produced white and “spotted” animals. Self coloured animals have not been observed.
White, “spotted” and self coloured animals were observed on segregation between full white (FW) and self coloured (SC) animals.

CONCLUSION

Monofactorial hypothesis of inheritance could be accepted to explain the genetic relationship between self coloured (SC) and irregular spotted (IS) animals because spotted animals were born from self coloured parents (see table 1). The same situation is described in several domestic mammals (Searle, 1968 ; Silvers, 1979). SC could be therefore considered as autosomal dominant to IS. In spite of this, there is a disagreement between this hypothesis and the results of both SC x IS (lack of recessive spotted animals, see table 2) and IS x IS segregations (self coloured animals born from spotted parents, see table 3). The disagreement could be explained in term of misclassification of some spotted parents. A phenotypic mimetism between recessive irregular spotting and some forms of dominant spotting or heterozygous white with incomplete penetrance is described for several mammals such as mouse, cattle, goat, horse (Searle, 1968 ; Silvers, 1979 ; Ricordeau and Lauvergne, 1971 ; Lauvergne *et al*., 1991 ; Adalsteinsson *et al*., 1994 ; Lauvergne *et al*., 2000). The mimetism could exist also in llama, as observed by Gandarillas (1971). The results of segregations including FW cannot clearly explain the inheritance of this phenotype. In the segregation between full white (FW) and self coloured (SC) animals, white appears as dominant on no white condition, because no white animals were born from SC x SC crossing. These results confirm the observations of Gandarillas (1971). Among the several mechanisms for full white described in mammals (Searle, 1968 ; Silvers, 1979 ; Ricordeau and Lauvergne, 1971 ; Adalsteinsson *et al*., 1994), two could be carried out in the analyzed segregations : a) the segregation of a dominant white factor ; b) the selection for a complete extension of IS. First hypothesis could be justified by the results of FW x SC segregation because the (FW + spotted) / SC ratio is very high. The second hypothesis is justified by the large number of spotted offspring born in every segregation. Both mechanisms are phenotypically mimetic and epistatic on the other colour phenotypes, including IS. The segregation of “spotted” animals could be finally explained with both hypothesis : the incomplete penetrance of dominant factor and the contemporary segregation of hypostatic IS.

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