

THE MOST LIKELY INHERITANCE OF HETEROCHROMIA IRIDES IN A MERINO FLOCK

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SUMMARY

The hypothesis that heterochromia irides occurring in white Merino sheep is inherited as a simple autosomal trait was investigated. The source of the abnormality in a Merino flock of the “Cypress Hill” stud appears to arise from a ram named “Polaris” and through five of his sons and two of his daughters. The observed occurrence of lambs with heterochromia irides among the progeny of seven affected rams mated to affected ewes was 90.5 % (n=21). When the affected rams were mated to unaffected ewes, that had previously produced an affected lamb or were daughters of affected rams, the incidence of affected lambs was 28.6 % (n=49). The outcome of mating the affected rams to the unaffected daughters of unaffected rams that had previously produced affected lambs was 15 % of the progeny (n=107) with heterochromia irides. These results are inconsistent with expectations for the inheritance of a fully penetrant recessive autosomal gene – other factors are apparently involved that limit occurrence of this eye abnormality.

Keywords: Heterochromia irides, Merino sheep

INTRODUCTION

Heterochromia irides in white Merino sheep was first reported by Lang (1995) and involves a white to light blue colouration of part or all of the anterior of the iris in one or both eyes and usually present as a white segment closest to the nostril. A similar eye abnormality trait with coat colour dilution is reported (Ojo and Leipold 1976) for Friesian cattle, involving four calves from sire-daughter matings, and believed to involve a simple autosomal gene. Dalmation dogs with blue-eyes tend also to be deaf and an autosomal recessive gene with incomplete penetrance appears to be involved (Griebrokk 1994).

Eliminating wool pigmentation and reducing non-wool pigmentation are traditional interests of Merino breeders. In 1992 the first sheep with heterochromia irides, a ram named “White Eyes” and grandson of the unaffected ram “Polaris”, was mated in the “Cypress Hill” stud. The possibility considered was that this visible eye pigment deficiency is simply inherited, does not cause adverse effects and reduces unwanted pigmentation. This paper reports the results of planned mating to determine whether heterochromia irides in the “Cypress Hill” Merino flock is inherited as a simple autosomal recessive trait. Observed trends in other pigmentation are also noted.

MATERIALS AND METHODS

Seven rams with heterochromia irides were selected for matings to test the mode of inheritance of this abnormality. All of these rams had a common ancestor, named “Polaris”, that appears to be the original source of the eye abnormality. The abbreviated pedigrees and scores for heterochromia (% of iris affected in right or left eyes) of the seven rams are:

- **WE6** (15 %, one eye) ← ram White Eyes ← ram Polaris 542 ← ram Polaris
- **P-53-F** (15 %, one eye) ← ram Puma 53 ← ram Puma ← ram Polaris
- **K2** (90 %, 40 %) ← ram Key ← ram White Eyes ← ram Polaris 542 ← ram Polaris
 ← affected ewe ← ram J19 ← ewe ← ewe ← ram Polaris
 ← ewe ← ram PolH490 ← ram Polaris
- **K3** (45 %, 60 %) ← ram Key ← (as above)
 ← unaffected ewe ← ram J19 ← (as above)
- **Phar Lap** (5 %, 20 %) ← ram Panda ← ram Pan5 ← ram Panther ← ram Polaris
 ← ewe ← ewe ← ram PolH490 ← ram Polaris
- **Pablo** (15 %) ← ram Panda (as above)
 ← ewe ← ewe ← ram Panther ← ram Polaris
- **Key** (70 %, 40 %) ← ram White Eyes ← Pol542 ← ram Polaris
 ← ewe 8445 ← ram Pol533 ← ram Polaris

With consideration of the experimental requirements of the test the rams were mated to groups of ewes including the following phenotype and assumed genotype categories:

- Those with heterochromia irides (assumed homozygous for the proposed recessive gene).
- Unaffected ewes that previously produced an affected lamb (assumed heterozygous).
- Unaffected daughters of affected rams (assumed heterozygous).
- Unaffected daughters of unaffected rams that had produced affected progeny.
- Random selection of unaffected ewes with no previous history of the abnormality.

The matings were conducted during 1996, 1997 and 1998. Each group of ewes was mated first to one affected ram for 6 weeks and then “backed-up” after a two week gap with another affected ram for a further 4 weeks. Lambs born from sire P-53-F, including most of the observations from ewes with heterochromia irides, were mothered daily during lambing. In this case, only one death of an affected lamb was recorded. Lambs born from other sires were mothered in the periods arising from the gap between the primary and secondary matings and after the second mating. The results of these matings, with both sexes combined, are shown in Table 1. Most of the affected lambs (n=58) and a sample of the normal lambs (n=106) were scored for pigmentation on the nose and eye lids. This score was assessed either soon after birth (sire P-53-F) or at the end of each lambing period.

RESULTS AND DISCUSSION

Examination of pedigree records suggests that the heterochromia irides originated from a ram named Polaris and has been carried forward often undetected for up to five generations. There were more affected male lambs than affected female lambs but this difference was not significant ($P>0.05$). Impaired sight or hearing and adverse effects on survival have not been evident based from the field behaviour and survival of greater than 78 sheep with heterochromia irides. Table 1 shows the number of lambs with heterochromia irides from affected rams mated to affected ewes and unaffected ewes of different assumed genotypes. Affected rams mated to a random selection of unaffected ewes with no previous record of heterochromia irides produced 8.8 % of affected lambs but when mated to affected ewes the proportion of affected lambs was 90.5 %.

Table 1. Number of lambs with heterochromia irides (A) or normal (N) iris pigmentation from mating of seven affected rams to five categories of ewes

Ram	Ewe Category – phenotype and assumed genotype for heterochromia irides									
	Ewes with heterochromia - all homozygous		Unaffected ewes with affected progeny – all heterozygous		Unaffected daughters of affected rams – all heterozygous		Unaffected daughters of 'carrier' rams - about half heterozygous		Random - low level of heterozygotes	
	N	A	N	A	N	A	N	A	N	A
WE-6		1	6	3	1	2	43	6	105	9
P-53-F	2	10	4	1	10	5	7	2	12	4
K2							15	6		
Phar Lap		4	1		8	1	1			
Pablo			1	1	2		6			
K3							5			
Key		4	2	1			14	2	17	
Total	2	19	14	6	21	8	91	16	134	13
(%)	(9.5)	(90.5)	(70)	(30)	(72.4)	(27.6)	(85)	(15)	(91.2)	(8.8)
Expected %	0	100	50	50	50	50	75	25		

These results reflect a recessive (or dominant-negative) inheritance though the occurrence of normal progeny from affected parents is not consistent with a simple inheritance unless some affected progeny were unable to be detected due to low expression or errors in pedigree records occurred. The segregations from ewes assumed to be heterozygous involved a total of 14 affected progeny in a total of 49 and this incidence (28.6 %) is significantly lower than expected (Chi-square = 9.0 $P < 0.005$). Similarly, there were less affected progeny than expected from the unaffected daughters of assumed carrier rams. It is concluded that heterochromia irides, as currently assessed from visually discernible de-pigmentation of the iris, is not simply inherited.

The possibility remains that an identifiable recessive gene is involved in allowing the occurrence of heterochromia irides but other factors or limitations in detection reduce penetrance. Only 2 of 21 progeny from parents that were affected were recorded as having normal iris pigmentation. From this result it could be inferred that low expressivity and inability to detect gene effects was not the only factor involved. Expression of heterochromia irides may depend on the presence of other independent genes as is the case in the Norway rat (Macy *et al.* 1972) or there may be reproductive limitations associated with the gene determining heterochromia irides. However, there was no observed higher incidence of deaths of lambs with heterochromia irides and the percentages of ewes lambing in mating groups were within normal commercial expectations. Heterochromia irides or white spotting genes sometimes involve effects on fertility or embryonic loss (eg. Adalsteinsson 1970; Macy *et al.* 1972; Belyaev *et al.* 1975) but clarifying this possibility was beyond the scope of this field investigation.

Heterochromia irides is often reported in association with or as a pleiotropic effect of dominant white spotting genes that affect the coat. Such reports include the Merle pattern in dogs (Sorsby and Davey 1954), dominant white in horses (Pulos and Hutt 1969), cattle (Leipold and Huston 1968), cats and

dogs (Bergsma and Brown 1971; Delak 1984; Strain 1991), pigs (Wegner 1973) and foxes (Belyaev *et al.* 1975), the dominant hooded pattern in rats (Macy *et al.* 1972) and Waardenburg syndrome in humans (Bergsma and Brown 1971). White coat pattern in Alpaca can also involve iris heterochromia. Impaired hearing and, or, reduced reproduction are sometimes associated with white spotting or heterochromia irides (Pulos and Hut 1969; Macy *et al.* 1972; Griebrokk 1994; Cable *et al.* 1994; Fleischman 1993). However, the gene for dominant white (*KIT*) in Large White and Landrace pigs does not appear to confer disadvantages in commercial production (Moller *et al.* 1996).

It appeared that affected animals had less skin and hoof pigmentation than usual in the flock. However, among the progeny from affected rams, the lambs with heterochromia irides did not have a markedly lower mean skin pigment score than normal progeny. The number of affected progeny without pigmentation on the nose and eye lids (score 0) was higher than among normal progeny (66 % vs 51 %) but this difference was not significant ($P>0.05$). Further study is needed to identify the molecular genetic basis of heterochromia irides in Merinos.

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