INHERITANCE PATTERNS OF NOSE AND COAT COLORATION IN CATTLE

by

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ABSTRACT

Title: Inheritance Patterns of Nose and Coat Coloration in Cattle

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Project Summary: Investigations into three areas of color and body spotting inheritance:

1) Black tipping in Gray Brahman
2) Nose color inheritance
3) Baldface-paint patterns

References:

Anderson, et. al. 1957. Studies on bovine ocular squamos carcinoma. J. Anim. Sci. 16:739.

Berge, S. 1961. Inheritance of muzzle colour, muzzle ring, and black hairs on the head of red cattle. Agricultural College of Norway, Vollebek.

Olson, T.A. and R.L. Wilham. 1982. Inheritance of coat coloration and body spotting patterns of cattle: a review. Iowa State Research Bulletin 595.

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I. Introduction

In the past, livestock color patterns have been mostly a matter of "eye appeal" or breed identification, and are generally not associated with actual performance. But the livestock breeder can receive several benefits from the study of color inheritance; including benefits related to production characters.

In Hereford cattle, those animals with pigment around the eyes and over the eyelids are less susceptible to cancer eye (Anderson et. al., 1957). Cancer eye can render cattle blind, making it difficult to eat or drink. At one time this pattern was selected against by Hereford breeders until it was understood that this pigment protected the eye from ultra violet rays.

In areas of limited sunlight, such as in Scandinavian countries, swine with lighter pigmented skin can more readily synthesize vitamin D than can darker pigmented hogs (Bogart, 1959).

In crossbreeding programs and in the formation of synthetic breeds, a uniform color and/or spotting pattern may be desired. An understanding of color and spotting inheritance would be essential in attaining this goal.

An understanding of color inheritance can also be valuable to the student when studying qualitative characters. Mendelian ratios and interaction among gene loci can be observed, and even applied to biochemical pathways.

This paper discusses three problems on cattle coat color inheritance and body spotting. These problems are:

1. Black ear tipping in Gray Brahman cattle.
2. Nose color inheritance.
3. Baldface-paint patterns.

II. Black Ear Tipping in Gray Brahman

In Gray Brahman cattle, approximately one-fourth exhibit a pattern depicted by the distribution of black around the edges of the ear. In some cases, only the lower border is black. Cattle which display this tipping pattern also have a "coal black" nose with no incidence of "split-nose," where a line of lighter pigment extends vertically down the nose and along the edge of the upper lip.

Females exhibiting black tipped ears also have black pigment extending from the vulva to the udder. The males express black also on the tip of the scrotum and around the preputial ring. All tipped calves are born red and turn gray as they mature, generally being a little darker than non-tipped cattle. The non-tipped calves are white or light gray at birth.

This pattern is also present in most Red Brahman, Tarentaise, and some Jersey cattle. In Jerseys, there is little variation in the expression of the pattern, where the entire ear is circled in black.

Literature Review

At the present, no work has been published on black tipped ears in cattle.

In his discussion on cattle coat colors, Olson (1982) suggested a hypothesis for the color pattern in Gray Brahman cattle.

$$E^{+}\_\ c^{ch}c^{ch}\ a^{tp}a^{tp}$$

He suggested the presence of the wild-type gene, E^{+}, at the E-locus, which expresses both red and black pigments. This pattern is modified by the chinchilla gene, c^{ch}, and the Zebu tipping gene, a^{tp}, which prevent the production of most of the red pigment and alter the expression of black pigment, respectively.

Note that Zebu tipping refers to an agouti-type pattern where the hair follicles are banded and should not be confused with the black ear tipping where black is distributed around the edges of the ear.

Materials and Methods

The data was taken from the Gray Brahman herd at the Texas A&M Beef Center, College Station, Texas. Fifty-one head were scored as being tipped or non-tipped. Fourteen or 27.5% were tipped. Sires and dams for each animal were then recorded. Phenotypes were unavailable for one or both parents of eight of the older cattle in the herd. Matings were then classified as to whether tipped or non-tipped progeny were produced.

Discussion

From the data, it was concluded that the black tipping pattern was inherited as a simple recessive. By observation, matings of tipped parents always produced tipped offspring. Suggested genotypes are:

Homozygous dominant:	TT	non-tipped
Heterozygote :	Tt	non-tipped
Homozygous recessive:	tt	tipped

In the statistical analysis, matings were divided into four groups:

1. Known carriers x known carriers
2. Known carriers x tipped
3. (Non-tipped daughters of known carrier x known carrier) x known carrier
4. (Non-tipped daughters of known carrier x known carrier) x tipped

Carriers were identified as the offspring of a tipped parent, or by producing tipped offspring. To avoid bias, the first tipped calf born of a non-tipped parent was eliminated from the data set. Since some carriers were identified in this manner, using the first tipped calf would bias the fraction of tipped offspring upward. Six matings were disregarded due to this type of bias.

If a carrier was identified by being the offspring of a tipped parent, all progeny available were used in the data set since the animal was a known carrier at birth.

Unknown genotypes consisted of non-tipped cattle that were not offspring of a tipped parent and had not produced any progeny or had produced only non-tipped offspring.

When mating known carriers with known carriers (Tt x Tt), we have a simple dihybrid cross and can expect one-fourth of the offspring to be tipped.

In known carrier by tipped matings (Tt x tt), one-half of the progeny would be expected to be tipped.

When known carriers are mated, two-thirds of the non-tipped offspring would be carriers. When these non-tipped daughters are mated with known carriers, one-sixth (2/3 x 1/4) of the offspring would be expected to be black tipped. When these non-tipped daughters are mated to tipped sires, one-third (2/3 x 1/2) of the offspring would be tipped.

Table 1 summarizes each mating group.

Table 1: Mating Summary

Group	no. matings	no. tipped offspring observed	no. tipped offspring expected
carrier x carrier	6	0	1.50
carrier x tipped	8	5	4.00
(daus. of carriers) x carriers	1	0	0.33
(daus. of carriers) x carriers	0	0	0.00

Since none of the matings fell in more than one category, the results were cumulated for Chi-square analysis in Table 2.

Table 2: Chi-Square Analysis

no. matings	no. tipped offspring observed	no. tipped offspring expected	$\frac{(O-E)^2}{E}$
15	5	5.83	0.118

$$\sum X^2 = 0.118$$

n = 15

degrees of freedom = 1

P = 0.7-0.8

Conclusion

From the results in Table 2, we can conclude that there is a 20-30% probability that this proportion of tipped offspring could have occurred by chance. Also in 70-80% of similar trials, deviations as great as these can be expected due to chance.

Considering the small data set, the hypothesis that black tipping is inherited as a simple recessive should be further tested. Data should be collected from several generations in more than one herd of Gray Brahman. This would also provide an estimate of the frequency of the "t" gene. In the TAMU herd, $q \doteq 0.52$, and appears to be higher in frequency than in other herds, although there was no apparent selection for this character.

III. Nose Color Inheritance

Through a better understanding of nose color inheritance, we could predict phenotypes for particular crosses. In the case of dark-nosed crossbreds, the breeder may be able to ascertain whether the animal comes from a wild-type base or from either a Holstein or an Angus base.

Berge(1961) suggested one locus involved in nose coloration with two alleles, V_k and V_s. The homozygote, V_sV_s, resulted in a slate or dark colored nose and V_kV_k resulted in a pink or light colored nose. The heterozygote, V_sV_k, was hypothesized to be ambivalent, with equal frequencies of light and dark.

This appears to be an oversimplification of nose color inheritance. At the Texas Agricultural Experiment Station at McGregor, 100% of the Angus-Charolais F_1's were dark-nosed. However, when Charolais bulls were mated to wild-type breeds (Brahman, Jersey, and Brahman-Jersey crosses), 1/8 to 1/3 of the calves exhibited light noses. This coincides with data reported from Raymondville, Texas, where Indu-Brazil bulls were bred to Charolais females; 70% of the calves were dark-nosed and 30% light. In a backcross with Indu-Brazil sires, 90% of the offspring had dark noses and 10% had light noses.

McGregor results are summarized in Table 3.

Table 3: Nose Color Results from Charolais--Wild-Type Crosses

Breed Cross	no. matings	no. dark-nosed offspring	no. light-nosed offspring
Char. x Brah.	7	5 (71%)	2 (29%)
Char. x Jer.	3	3 (100%)	0 (0%)
Char. x Brah.-Jer.	8	7 (87.5%)	1 (12.5%)
Combined Data	18	15 (83%)	3 (17%)

A statistical analysis indicated no significant difference ($\alpha = 0.05$) between proportions in each mating. Since the data deals with a rather small sample size and nose color is a matter of personal judgement, there is some error involved.

Discussion

By looking at the data, nose color appears to be affected by modifier genes. Consider a segregating gene I in Charolais cattle which would inhibit the black nose color when Charolais are mated with wild-type cattle.

Applying this to the data reported from Raymondville, 30% of the Charolais females transmitted the gene I to their offspring, resulting in a light nose color. Assuming heterozygousity at this locus in 30% of the F_1 females, the inhibitor gene I will be transmitted one-half of the time, resulting in 15% of the calves having light noses in a backcross with Indu-Brazil bulls.

	Indu-Brazil		Charolais
P_1	E^+E^+ii	x	ee ii <u>or</u> ee Ii
	(black)		(light)

F_1	70%	E^+e ii	dark
	30%	E^+e Ii	light

In the backcross:

P_1 E^+E^+ii x 70% E^+e ii & 30% E^+e Ii

F_1 35% E^+e ii
35% E^+E^+ii — all dark noses

7.5% E^+e Ii
7.5% E^+e ii
7.5% E^+E^+Ii
7.5% E^+E^+ii

15% light (E^+e Ii, E^+E^+Ii)
15% dark (E^+e ii, E^+E^+ii)

An epistatic situation also may fit the data where I inhibits black nose color in the heterozygote, $E^{+}e$, and does not express itself in the homozygote, $E^{+}E^{+}$, for wild-type black nose color. If this were the case, 7-8% of the calves from a backcross would have light noses.

Further study of backcross data would certainly give a better indication of how nose color is modified in Charolais crosses. Some bias may be invoved with Charolais cattle when an animal has been graded up. In this case, it is possible to retain the gene for dark nose color from a wild-type base.

IV. Baldface-Paint Patterns

Review of Literature

In a study by Franke (1975) involving Hereford cattle from Miles City, Montanna, fourteen out of 176 calves exhibited apparent recessive body spotting, ss. These calves also exhibited a Hereford facial pattern.

Olson (1982) suggested two genes being responsible for this facial pattern; one being the S^H gene which expresses the typical Hereford pattern, the other was the "blaze" gene responsible for the facial pattern in Simmental cattle.

Olson's hypothesis also suggests that the expression of Bl or blaze gene, is influenced by alleles present at the spotting locus. In a non-spotted animal, S^+S^+, or S^+ s, the Bl gene is expressed as a restricted pattern where a stripe extends down over the face. In a recessive spotting situation, ss, the blaze gene produces a white head as in typical Hereford cattle.

In Olson's hypothesis, he suggested that the Bl gene is responsible for the facial patterns in the Hereford baldface-paints at Miles City. He also mentioned that the gene was also present in Charolais and Holstein cattle.

Discussion

At the Texas Agricultural Experiment Station at McGregor, when Charolais were mated with non-spotted breeds, S^+S^+, such as Angus, none of the offspring exhibited a blaze pattern, restricted or full. Two Hereford-Charolais crosses did possess the baldface-paint pattern.

In Hereford-Holstein matings, all the calves displayed the typical Hereford pattern. In this situation, if the Bl gene were transmitted by the Holstein, the Hereford pattern would mask its expression.

In crosses involving Charolais and non-spotted breeds, the data indicates that Bl is not even present in the breed. Facial patterns in Holsteins depicting the blaze pattern may only be the result of recessive body spotting at the S-locus extending over the face. Six crosses involving Holstein did result in restricted blaze patterns but it is difficult to distinguish whether this cam e from the blaze gene or the recessive spotting gene.

Facial patterns in both Simmental and Hereford cattle may be a result of common origin followed by artificial selection. The pattern described by Franke in the Miles City cattle is not uncommon in the Simmental breed. One possibility exists where the Hereford facial and body spotting patterns are inherited as separate, non-allelic genes on the same chromosome, in a linkage situation, which could be interpreted as a single gene. Recombination by crossing over, or a mutation could result in the facial pattern being linked with the recessive spotting gene.

Conclusion

A study of Simmental cattle may provide more information on the baldface-paint pattern. The incidence of baldface-paints is much higher in Simmentals providing a chance for more extensive research. However, observations at McGregor did indicate that the blaze gene was not present in Charolais cattle.

V. Summary

Three investigations in cattle nose and coat color, and body spotting inheritance did result in several hypotheses.

In Gray Brahman cattle, black ear tipping appears to be inherited as a simple recessive.

Wild-type nose color from the E^{+} gene appears to be modified by an inhibitor gene, I, found in Charolais cattle. In Angus cattle which do not possess the wild-type gene, black nose color is not affected by the inhibitor gene.

Observations at Mc Gregor suggest that the blaze gene is not present in the Charolais breed.

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