INHERITANCE OF BLACK HAIR PATTERNS IN CATTLE LACKING THE EXTENSION FACTOR FOR BLACK (E). IV. PARTITIONING PHENOTYPES BY CASTRATION[2]

L. O. GILMORE, N. S. FECHHEIMER, AND C. S. BALDWIN[1]
Department of Dairy Science, Ohio Agricultural Experiment Station, Wooster

The appearance of blackish hairs in genetically red cattle (Jerseys and Ayrshires) was shown by Baldwin et al. (1954) to be affected by genotype, sex, and age. They pointed out that the areas on which these hairs are found under

[1]Present address, Central Ohio Breeding Association, Columbus.
[2]Journal Article No. 57-61, The Ohio Agricultural Experiment Station.

THE OHIO JOURNAL OF SCIENCE 61(5): 273, September, 1961.

different conditions are eye, cheek, muzzle, ear, neck, shoulder, body, rump, legs, and switch. They differentiated between blackish and black hairs, microscopically, and showed that the frequency with which blackish hairs were found was different for various parts of the body. It was concluded that the presence of blackish hairs on the head depended on the presence of the *Bs* gene. Those on the body and rump were concluded to depend on a pattern modifier, Bp_m, which exhibited sexual dimorphism in heterozygotes (Baldwin et al., 1956). A trait characterized as exhibiting sexually dimorphic reversal of dominance is also known as sex-influenced.

Pattern baldness in man has been shown to be caused by a sex-influenced gene (Snyder and Yingling, 1935). When Hamilton (1942, 1948) studied this character in eunuch, eunuchoid, and castrate males, he was unable to detect the appearance of baldness. When, however, testosterone therapy was applied to four castrated men, patterned baldness began to appear; when the therapy was halted the progression of the baldness ceased. Other sex-influenced traits reviewed by Baldwin are scurs and a certain type of horns (African) in both sheep and cattle.

That Bp_m is a modifier of *Bs* has been questioned by Overton et al. (1958) who analyzed the data of Baldwin (1951) by a method of maximum likelihood to test the validity of assuming that the variations observed could be explained also by the action of three alleles, i.e., Bs_m, *Bs* and *bs*. Although they showed that an allelic hypothesis was also tenable for the Jersey data, it was rejected at the 5 per cent level of significance in the Ayrshire data.

TABLE 1

The effect of castration on the persistence of black hair patterns in Jersey males

	No. with Black Hair on Specified Areas					
Treatment	Head	Crest	Body	Leg	Switch	Ear
Before	16	15	14	12	12	2*
After	6	5	0	12	12	2

*Both had black fringe hairs.

Hancock (1952) concluded from the observations on nearly 300 sets of identical twins that *Bs* has the pleiotropic effect of producing a strip of brown on the generally black skin extending from the lower jaw along the ventral line to the analvulvar region and along the inside of the tail. There may be a break in the brown skin under the neck. The inner surface of the ear as well as the lower portion of the outer surface is also brown skinned. Hancock found that there frequently occurred a characteristically shaped black pigmented area on the brown skin inside the ear (ear streak) and on the ano-vulvar region (a-v spot). The bilateral symmetry of the whole of this skin color pattern was so marked and the concordance between identical twins so great as to warrant the conclusion that all variations except those resulting from conditions of housing and lactation must be explained genetically. In a further effort to explain different genetic causes for the black hairs on red cattle, Hancock proposed the existence of a third gene, a simple recessive, *be*, which, in homozygotes, possessing also the *Bs* gene differs from *Be/—Bs/—*cattle by having only the skin of the udder, belly, brisket and the upper two-thirds of the inner surface of the ears brown while the rest is black. No intratwin pair differences were found with respect to the phenotypes of *be/be* animals. Because of the presumed interaction of *be/be* and *Bs*, the hair of the inner fringe of the ears is generally jet black.

After the observation by Baldwin (1956) that an Ayrshire freemartin, from parents both of which were nonblackish patterned, exhibited the pattern, the need to observe experimentally imposed castration effects was suggested. This was done on three Ayrshire bull calves. This experiment was concluded prematurely but, nevertheless, the blackish pattern on one of the bulls disappeared. The purpose of this paper is to report further pertinent observations that were made on 17 Jersey males, some of which were castrated for another experiment (Hibbs et al., 1959).

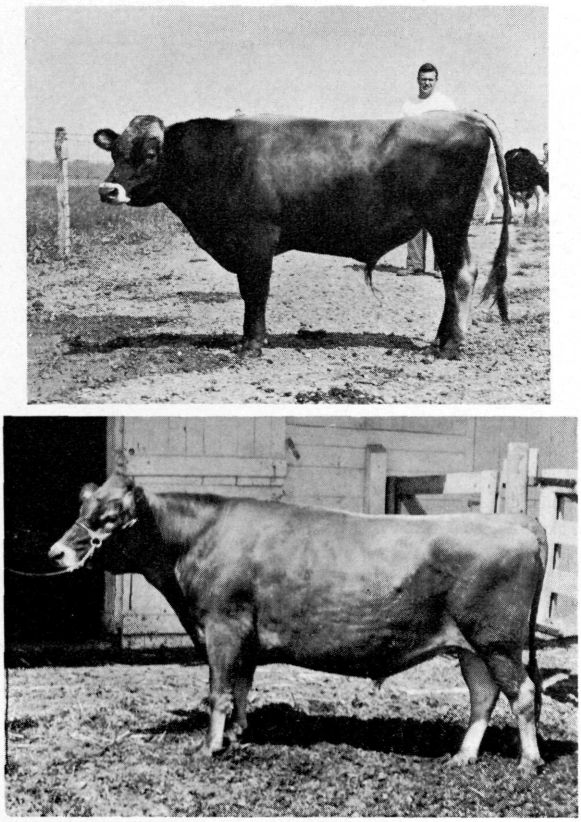

FIGURE 1. The blackish pattern disappears with castration. A. (top) Jersey bull, 19½ mo. old. B. (bottom) Same male 11½ mo. after castration, at 40½ mo. of age. The blackish pattern had completely disappeared.

EXPERIMENTAL PROCEDURE

Thirteen of the 17 calves were castrated at approximately six months of age by crushing the external pudic nerves and arteries with an emasculatome. Before castration and again at approximately 17 months, color slides were taken of each side of each animal. The other four bulls were castrated at an older age by gonadectomy, three at 11 months, and one at 23 months. These four were observed carefully as well as photographed at various times before and after castration.

From each photograph, or animal, information regarding the presence of black hairs on the head, ears, crest, body, legs, and switch was recorded.

RESULTS AND DISCUSSION

From the observations summarized in table 1, it is seen that the six areas studied can be divided into two separate categories, i.e., those areas which were uniformly unchanged by castration and those areas affected at least in some of the cases. In no case was there a change in the gross nature or the extent of the black hairs appearing on the tail and legs. From this it is concluded that the color expression of the black hairs in these areas are influenced by genes, the expression of which is not affected by sex hormones. While the same result was observed on the black hairs of the ears as on the legs and switch, there was an insufficient number of cases to justify a firm conclusion. Only two possessed the black hair fringe on the ear described by Hancock (1952) as caused by the interaction of *Bs* with the *be/be* genotype. In neither case, however, was a change noted in the appearance of the black hair fringe following castration.

From the observations made in this study, there is corroboration of the conclusion by Baldwin (1951) that the black hairs in the switch and on the legs are present at birth. Furthermore, it has been shown that the pattern of black hairs on the switch and distal part of the leg is not modified by brindling as are other areas of the body on which blackish hairs are found (Baldwin et al., 1954).

It has been observed that blackish hairs appear on the areas of the body other than legs and switch after approximately one month of age. The color expression may not be fully developed until 6 months or more in males and 2 to 3 years in females. The blackish hairs on the body (including rump and thigh) disappeared in all 14 cases in which it was present before castration (table 1, fig. 1). Thus, it appears that blackish pattern in cattle responds to male hormone withdrawal in the same manner as pattern baldness in man. For both head and crest, approximately one-third of the experimental subjects failed to lose the blackish hairs in each area; three failed in both areas. So far the relation between *Bs*, Bp_m, and *be* with different hormone levels has not been investigated with respect to either of these areas; neither has the possibility of a differential response to castration between the homozygote and heterozygote been excluded. It was impossible in the present material to make a satisfactory diagnosis of genotype from the pedigrees and no definitive matings were made.

SUMMARY AND CONCLUSIONS

Seventeen Jersey bulls were castrated after they became old enough to show blackish hairs on the head, ears, crest, body, legs, and switch. Within one year from the period of castration blackish hairs disappeared from the body, rump and thigh areas in all 14 animals showing pre-castration blackish in these areas. This is interpreted to indicate absolute dependence of Bp_m on the male hormone for its expression. In 10 out of 16 cases the blackish hairs of the head disappeared, indicating either a partial reliance of *Bs* on the male sex hormone, incomplete dominance or an interaction between hormonal function and the *Bs* alleles. A similar result for blackish or black hairs on the crest suggests the need for investigating the cause of their appearance in this area. In no case did black hairs disappear from the leg or switch. This is interpreted to indicate that these may be black instead of blackish hairs and that a separate genetic cause is responsible for their appearance.

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