COAT COLOUR GENETICS IN THE TULI BREED

Photograph courtesy of Dr Steven Lukefahr

TULI CATTLE HAVE A VARIETY OF COAT COLOURS, RANGING FROM RED TO YELLOW TO WHITE. **DR STEVEN LUKEFAHR** TAKES AN IN-DEPTH LOOK AT THE TULI BREED AND GIVES AN EXPLANATION FOR THE DIFFERENT COAT COLOURS.

The subject of coat colour in cattle is important from both an adaptation and economic standpoint. Dr Jan Bonsma clearly demonstrated this association in his pioneer research work at Mara Research Station. He identified certain colours that were either to the advantage or disadvantage of the animal. For example, an animal with a dark-coloured hair coat was at a disadvantage because it was more vulnerable to intense radiation of short-wave and heat rays that elevated body temperature, thus impairing the animal's physiological well-being and performance. In contrast, and to quote Bonsma, 'a white, yellow or red-brown coat with a dark hide is the ideal combination to render an animal resistant to temperature'.

The Tuli breed portrays a variety of coat colours, ranging from white to yellow to red (with all possible shades in between), but excluding black. Although the Tuli, at least by name, is a relatively recent breed, developed in the 1940s by Mr Len Harvey at the Gwanda Breeding Station, Zimbabwe, breeders have been puzzled over the nature by which coat colours are inherited. But, like all characters, coat colour is genetically influenced. All genes are inherited in pairs, one member being transmitted from each parent from a specific chromosome location (locus), and in accordance

Figure 1:
Breeding chart for predicting coat colours of calves from parental matings.

	Red (ww)	Yellow (Ww)	White (WW)
Red (ww)	ww Red	ww/Ww Red/Yellow	Ww Yellow
Yellow (Ww)	ww/Ww Red/Yellow	ww/Ww/WW Red/Yellow/White	Ww/WW Yellow/White
White (WW)	Ww Yellow	Ww/WW Yellow/White	WW White

Looking at any two red Tulis, upon close examination, it will soon become evident that they are not exactly the same shade of red.

to the same processes, the so-called Mendel's Laws of Inheritance. To solve any genetic mystery, the task is to determine how the gene is inherited and how it is expressed.

Tuli are basically red animals

According to Dr Fanie Kellerman (*circa 1979*), all Tuli cattle are basically red in colour. In other words, observed variations of colour deal only with shades of red, due to additional genes that interact with the red gene. In the genetics literature, the symbol, 'e', has been assigned to the red gene. Lower case e symbolizes a recessive gene. In several species that include cattle, red colour is attributable to low levels of tyrosinase (an enzyme required for the production of colour pigments). As a consequence, pigment-forming cells in the skin (called melanocytes) can only produce red rather than black pigments (that is a non-extension of black colour).

The first model assumption is that the same red gene, e, is prevalent in Tuli cattle. It has been observed in recent U.S. breed evaluation experiments, that when red-coloured Tuli bulls were mated to Black Angus cows that only black-coloured calves resulted. This is because Black Angus cows that breed true for colour (that is EE homozygotes), could only transmit the dominant E gene (extension of black colour). Therefore all calves produced were Ee genetically and black phenotypically. However, some Black Angus cows carried the red gene (Ee heterozygotes), which resulted in either black- or red-coloured calves. In addition, when red-coloured Tuli bulls were mated to red-coloured cows of other breeds (for example Red Angus and Senepol), the outcome was red calves, once again suggesting the same e gene.

A proposed major dilution gene

Kellerman also believed that a dilution gene was found in Tuli cattle. Based on parent-progeny records provided by Stephan and Carmen Welz, it is evident that yellow calves result from red x white matings. This outcome is similar to that of yellow-coloured calves that result from matings of Charolais bulls to red-coloured cows, such as Herefords. Further, matings of Charolais bulls to Black Angus cows produce 'smoke'-coloured calves, which is dilution of black. In addition, on several Texas ranches, the outcome of matings involving yellow Tuli bulls to red-coloured cows (for example, Red Angus and Senepol) is red- and yellow-coloured calves.

Parent-progeny records also indicate that yellow x white matings yield yellow- and white-coloured calves (but not red), and that yellow x yellow matings yield all three colours – red, yellow, and white.

It is proposed that a major gene exists for white dilution, 'W' (the same symbol is used by geneticists for dilution in other species). When W is combined with 'w' (no dilution), producing a yellow calf (eeWw) – this can be referred to as a single dilution effect of red colour. Since the calf is not white but yellow, this suggests that there is no dominance. If both parents transmit a W gene, producing a white calf (eeWW), this can be referred to as a double dilution effect of red colour. In Figure 1, a breeding chart is presented as a guide to show the expected outcomes from matings of parents with the same or different colours. Only red x red and white x white produce the same coloured calf, whereas a red x white mating would be expected to produce a yellow calf. A red x yellow mating would produce the same colours in their offspring, and likewise for a yellow x white mating.

It is the yellow x yellow mating in which all three colours are produced. Interestingly, this model is consistent with a quote by Harvey, when he justified his decision of sampling mostly yellow cattle from the Tribal Trust in Zimbabwe, that he would get all the other colours back in the next generation.

A group of pedigree Tuli calves.

Modifier genes

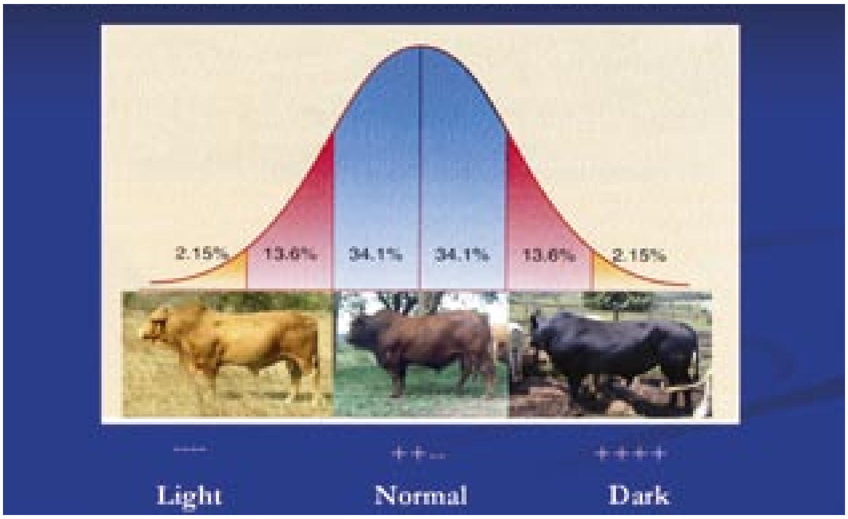
Looking at any two red Tulis, upon close examination, it will soon become evident that they are not exactly the same shade of red. The same goes for two yellow Tulis, or two 'cream' white Tulis. Modifier genes can explain this form of variation in colour. As the term implies, modifier genes modify colour. However, the number of modifier genes (also called minor genes) for colour is unknown.

One theory developed by geneticists is that a modifier gene can either lighten or darken the animal's colour. For clarity, a common analogy involves the use of negative and positive signs for lightening and darkening, respectively. Also, the greater the number of pairs of modifier genes the broader the spectrum of colour shades. A property of this phenomenon is that the classes or degrees of colour shades give rise to a bell-shaped curve or frequency distribution (Figure 2). In many Tuli herds, cattle exhibiting very light red colour or very dark red colour is less common to normal red colour, which is most common. Modifier genes also explain why a genetically red animal (eeww) actually appears yellow because of lightening modifiers, so as to be confused with a true yellow animal (eeWw), and for a yellow animal to appear either red or white, and for a white animal to appear yellow. Progeny tests may reveal the true genotype of a parent. Another application, if a breeder prefers a particular shade of red, matings involving animals of similar shade should eventually produce a herd with that shade. To illustrate, Red Poll cattle are predominately very dark red, as

An animal with a dark-coloured hair coat was at a disadvantage because it was more vulnerable to intense radiation of short-wave and heat rays.

Photograph courtesy of Charl Hunlun

Figure 2:
Graphical representation of modifier genes for red colour.



Further research is needed to determine if certain common colours are more important from an adaptation or economic standpoint.

opposed to Limousin cattle that are typically light red.

Dun or 'dagha' colour

Perhaps a major gene unique to the Tuli breed is the 'dagha' colour, which may represent another form of dilution. Dagha appears to resemble the dun recessive gene, 'dn', in terms of effects on colour. According to the literature, the dun gene fades or washes out red colour by diluting the concentration of red pigments in the hair coat, often leaving a brownish cast, while not affecting the extent of black pigmentation (Olson, 1999). Based on parent-progeny records, dagha appears to be due to a recessive gene; in the majority of cases, non-dagha parents produced dagha calves. The symbol 'dg' is proposed. The dun gene appears to be incompletely recessive because in heterozygotes there may be some effect on red pigmentation. It is conceivable that the dagha gene could be a member of the dun gene series of cattle (that is found at the same chromosomal location or locus) because of its similarities. For example, in some Tuli x Red Angus crossbreds, the dagha pattern has been observed, suggesting a similar incomplete recessive nature because Red Angus cattle do not possess the dagha gene.

A useful breeding experiment would be to examine the progeny from the mating of a dagha-coloured Tuli to a dun-coloured animal of another breed. Dun calves are born dun, and the colour is usually uniformly distributed over the entire body coat. In contrast, a dagha calf may not show signs of dagha colouration for months, even years. In other words, the expression of dagha colour may be to some extent age dependent. Also, dagha colouration is usually not uniform, but often shows as blotches throughout the hair coat. Modifier genes could account for both the extent and distribution of dagha colouration.

An animal with one or two copies of the dagha gene with a background genotype for dark red would conceivably produce a dark dagha coloured coat, often appearing as dark or chocolate red. A note of interest is that yellow Tuli cattle with dagha colouration are classified as 'duns'. Extremely white-coloured animals may not be affected by the dagha gene because of the double dilution effect of W, plus lightening modifiers. To date, potential advantages of dagha colour is unknown from a genetic adaptation standpoint.

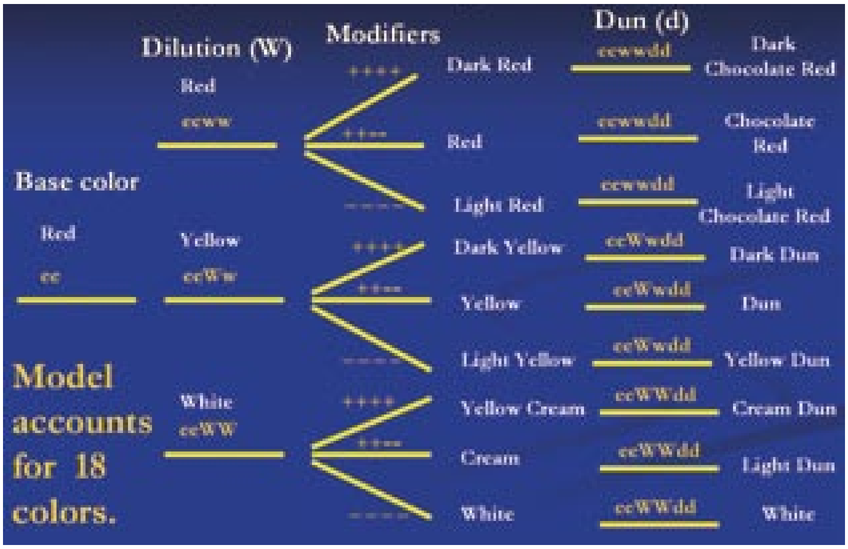
A proposed model

A model is proposed that consists of a set of hypotheses pertaining to gene expression for coat colours in the Tuli breed population, which accounts for 18 colours due to combinations of two sets of dilutions genes (white and dagha) plus modifiers that are imposed on basic red colour (Figure 3). For brevity and clarity, dg is shortened to 'd' in the figure. This figure is larger than that of Harvey who claimed that 13 colours existed in the Tuli breed. However, these hypotheses need to be confirmed through formal research investigations involving test matings. It is also possible that other major genes for colour exist (for example, brindling and brown), not to mention genes for colour patterns, such as diffusion or spotting.

Further research is needed to determine if certain common colours are more important from an adaptation or economic standpoint. For instance, some breeders have observed during periods of high ambient temperatures that red Tuli cattle tend to spend more time seeking shade and less time grazing than yellow or white cattle. Bonsma (1943) demonstrated in Afrikaner cattle that animals with lighter-coloured coats (cream, light yellow, and golden) tended to reflect more sunlight than those with darker-coloured coats (light red, red, and dark red).

If future well-designed experiments were to show advantages for lighter-coloured Tuli, an opportunity might exist to develop a specialised line of white- or silver-coloured Tuli for open savannah regions where cattle are generally more vulnerable to heat stress. For obvious reasons, it would be imperative that concomitant selection be made for dark pigmentation of the eyelids, hides, hooves, and muzzle. In conclusion, perhaps coat colour is more important than breeders realise. SA-STUD

Figure 3:
Master fan diagram for coat colour in Tuli cattle.



Photograph courtesy of Charl Hunlun

Tuli stud bull on the farm of Mr Stephan Welz.