S & CB (2001), **13**, 51–58 0954–4194

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A Mendelian Interpretation of Jacob's Sheep

The story of Jacob producing flocks of striped goats and black sheep starting from flocks in which these characteristics had been removed is considered from a Mendelian genetic viewpoint. Previous commentators have implied that the placing of branches in front of the animals arose from the belief that vivid sights during pregnancy would leave a mark on the offspring. However, the fact that Laban removed all the coloured animals from the flock he entrusted to Jacob, shows that the herdsmen knew that the colour of the offspring was influenced in some way by the colour of the parents. It was not necessary for the herdsmen to understand the exact rules of inheritance, only sufficient that, wherever possible, female animals were served by coloured males. It is proposed that the use of the branches referred to in the story was not an attempt to generate visual impressions influencing the females during pregnancy or conception, but instead the branches were used to build a fence to ensure that only coloured male animals could serve the females.

Keywords: Genetics, Jacob, sheep, goats, Mendel.

Introduction

The story of Jacob recorded in Genesis 30: 31-43 is considered as an account of an actual incident which could have occurred in a semi-nomadic farming community of the early second millennium BC in North West Mesopotamia (Haran). The understanding of this paper will benefit from a prior reading of this passage.

The story of Jacob and Laban was recorded thousands of years before Mendel's theory of inherited characteristics was proposed. It should not be assumed, however, that Jacob and Laban were not familiar with the inheritance of characteristics. Darwin gained some of his ideas from studying the large variation in pigeons and dogs, produced by 'fanciers', enthusiastic amateurs who recognised that some characteristics could be passed on from parent to offspring. Early man by selection improved the egg production of their domesticated fowl. So it is very reasonable to assume that Jacob and Laban understood that the fleece colour of their lambs and kids was influenced by the colour of the parents.

This paper takes the story at face value, and the principles of Mendelian genetics are applied to show how quickly the colour of the flock could have

been changed by an experienced shepherd. After fourteen years of working with sheep, Jacob must have understood the importance of using rams with the desired characteristics to pass on these characteristics to some of the lambs. It is shown below that with the assumptions given, the colour of the animals could be changed into the form desired by Jacob over the period of six years. Complicating the model presented may amend the figures quoted but would not invalidate the conclusions.

Biblical Commentary

Derek Kidner[1] suggests that Jacob in presenting the animals with striped rods at the breeding season was acting under the belief that vivid visual impressions during pregnancy would leave a mark on the embryo. Kidner adds that the belief includes vivid sights during conception. In the Genesis account, the female animals see the striped rods specifically during mating. Although there is an ancient superstition that events experienced by a female during pregnancy are reflected in the constitution of the child to be born, Kidner, as with other commentators[2-5], extends the belief to include sights during the actual mating.

From a scientific perspective, the action of simply showing the animals branches of trees could have no effect on the colour of the offspring. Kidner points out that some of Jacob's success came from selective breeding, but says that this by itself would have worked very slowly. Kidner suggests that God intervened, referring to Genesis 32: 9-12. However, this paper suggests that direct divine intervention was unnecessary; simple selective breeding would have achieved the stated result over the six years quoted. In fact, Genesis Chapter 30 does not claim that Jacob's success was achieved by the direct intervention of God. Nevertheless, in Chapter 31, Jacob does tell his wives that the male goats that are mating with the flock are streaked, speckled or spotted. He explains that an angel has drawn this to his attention. Jacob was perhaps acknowledging here that all knowledge comes from God, including his own particular knowledge of animal breeding.

Westermann[2], like Kidner, refers to the 'widespread notion that visual impressions at the moment of conception can effect the progeny of the animals'. He points out that passing down acquired knowledge of animal husbandry is of importance to herdsmen. Earlier commentators such as John Gill[3], Jamieson, Fausset and Brown[4] and Matthew Henry[5] all refer to the effect of sights at conception affecting progeny, although, like Kidner, they also refer to divine intervention.

1 Kidner, D. *Genesis Old Testament Commentaries*, Inter-Varsity Press (1976)
2 Westermann, C. *Genesis 12~36 a Commentary*, translated by Scullion, J. J. Minneapolis: Augsburg Publishing House (1985)
3 Gill, John *Exposition of the Entire Bible*, Baptist Standard Bearer (1995)
4 Jamieson. R., Fausset, A.R. & Brown D. *Commentary on the Holy Bible*, Grand Rapids: Zondervan Publishing House, (February 1999)
5 Henry, M. *Commenary on the Whole Bible*, Peabody Massachusetts: Hendrickson (1991)

The Genetics of sheep colour

There are 11 genetic loci affecting sheep colour[6]. The colouring is due to the presence of melanins in skin and hair produced by melanocytes. The two main mechanisms by which pigmentation is reduced or absent are by relative inactivity or absence of the melanocytes.

White is obviously a very important colour type in sheep to the extent that coloured sheep are very much in a minority in most countries and most breeds of sheep. For white sheep the most important locus is the Agouti, with 17 identified alleles, the most dominant allele being white (A). The locus is responsible for the formation of a protein that nullifies the actions of the melanocytes. The importance of the white allele (A) is explained by Mongold[7] as follows:

"White is considered a pattern not a color. This pattern could also be called Absence of Color, because when the animal carries this pattern gene, it turns off all of the color-producing cells in the hair (wool) follicles. In other words, this white pattern gene nullifies the basic color gene. This pattern is so extensive that it masks all the base color so that you cannot tell whether the base color is black or brown".

The type of sheep in Laban's flock is not known. However, it can be deduced that most of the animals had white wool. It would not have been sensible for Laban to agree to Jacob's proposal on wages (Ch.30 verses 32, 33) if white sheep were in the minority.

Description of the animals

The goats fall into two groups: the first group, which are to be Jacob's wages, have stripes, spots or speckles on a dark fleece, and the second group, which are to remain as Laban's animals, are those without these markings on a white background. The sheep also fall into two groups: The first group, which are to be Jacob's wages, have speckles or spots or are all black, and the second group, which are to remain as Laban's animals, are the white sheep.

It is apparent that some understanding of inherited characteristics was known at the time of Jacob. Laban believed that the action of removing all the black sheep from the flocks given into Jacob's keeping would prevent the birth of black lambs. Jacob had had a lot of experience in flock management over the fourteen years he had worked for Laban to buy Leah and Rachel (Genesis 30: 30). In Genesis 31: 10-12 he tells his wives that the male goats that mated were striped, spotted or speckled, explaining the appearance of the speckled kids. Whether this selective mating was accidental ('I saw in a dream') or occurred under Jacob's experienced shepherding is open to discussion, but Jacob throughout his life showed a great aptitude in deception. Jacob clearly under-

6 Piper, L. & Ruvinsky, A. *The Genetics of Sheep*, Wallingford Oxfordshire: CABI Publishing (1997)
7 Mongold, S. 'Color genetics in Icelandic sheep', *The Shepherd* (1997) 42(6), 11-16

stood that the chances of producing kids with markings were substantially improved by a female goat mating with a male goat with markings. In proposing the deal to Laban, Jacob was no fool, as other passages in Genesis make clear, since he apparently thought that he could ensure black sheep were produced from the flock using the black rams. He did not expect Laban to remove the black rams, and he did not know black lambs would 'naturally' appear in the next generation. It perhaps could be argued that the action of Laban in removing the coloured animals was simply denying Jacob his first years salary. However, Westermann[2] argues that Laban was preventing Jacob the use (for selective breeding) of these animals.

Jacob must have been very upset on finding that he was starting with no animals of the desired characteristics. He must have been delighted after the first year's breeding to find a few such animals, indeed it may have provoked him in telling his wife of the visit of the angel.

Assumptions

Consider the characteristics of a flock of sheep or goats in the Middle East some 4000 years ago:

- The size of the flocks would remain approximately constant year to year, excess animals being killed for meat.

- There would be approximately equal numbers of male and female animals born.

- There would be many more female animals than male animals at the time of reproduction; that is, there would be culling of a greater proportion of male than female sheep, fatted calves being generally male. In Gen.32: 13-15, Jacob presents Esau with 200 female sheep and 20 male sheep.

- There would be no attempt to emphasise a particular characteristic. (This would not be the case with either Laban or Jacob after they struck their agreement, described in Gen. 31:32). There was no advantage or disadvantage to the animal or its owner in having a particular fleece colour or pattern, so there would be random mating of the animals.

- Animals would be allowed to graze over a wide area only restricted by the shepherd. Laban took the black sheep and speckled goats three days journey from the flock managed by Jacob, presumably over open country.

- There was a very specific time of mating during the year. This is the case today with both wild and modern domesticated sheep and goats (cf. Gen. 31:10).

- In modern sheep management, the majority of male lambs are castrated shortly after birth. It is assumed that this was not the case in early Biblical times, but if this was the practice, the reason for the predominant black flock

after six years of Jacob's management is more obvious. In reference 6, page 20, mention is made of Neolithic horn cores, intermediate in size between rams and ewes, giving evidence of castration.

Mendelian Genetics

For this paper only the sheep will be considered. It is assumed that the colour of a sheep's fleece is controlled by alleles at a single locus, the *white* (A) being dominant over all other alleles (a). This is a simplification but is justified on the grounds that this allele contributes the majority of the variance in this character.

A white sheep has either 2 *white* (A) or 1 *white* (A) and 1 *wild type* (a), and a coloured sheep has 2 *wild type* (a).

In a free random breeding flock the ratio of types would be as follows:

Homozygous (AA) $(1-x)^2$

Heterozygous (Aa) $2 x (1-x)$

Homozygous (aa) x^2

where it is assumed that the ratio of the white allele (A) to the wild allele (a) is

1 - x: x.

To what sort of deal would Laban and Jacob agree? Let us assume that 11% (x = 1/3) of the flock were black when the deal was agreed. This could have been acceptable to both parties. With a much higher percentage, Laban would not have agreed, with a much lower figure Jacob would not have agreed. Westermann[2] believes a clear and controllable offer would appeal to the avaricious Laban. In a free (random) breeding flock with random culling of both black sheep and white sheep there would be the following proportion of types:

44.44% homozygous white sheep (viz with two dominant genes)

44.44% heterozygous white sheep (viz with 1 dominant and 1 recessive gene), indistinguishable from the homozygous sheep

11% black sheep

This gives a higher proportion of black sheep than is found in English flocks, black wool not commanding as high a price as white wool. It is reasonable to assume that there has been a degree of selective breeding in the modern flocks but, significantly, the recessive wild allele has not been eliminated.

Laban upset the *status quo* when he removed all the black sheep from the flock, which then contained equal numbers of sheep of genotype AA and genotype Aa (although of course neither Jacob nor Laban knew that!). Obviously the choice of the particular value of x is to simplify the following analysis, but does not invalidate the general argument. If this flock were allowed to freely breed, the following patterns would result:

AA x AA

	A	A
A	AA	AA
A	AA	AA

Aa x Aa

	A	a
A	AA	Aa
a	Aa	**aa**

Aa x AA

	A	a
A	AA	Aa
A	AA	Aa

Thus, one twelfth of the offspring would be black (highlighted in the table) and the rest would be white. One third of the offspring would be heterozygous (Aa), having the recessive allele (a).

It can be argued that Jacob did not understand enough about genetics to set up a breeding programme. But what he did know is that the chances of producing a lamb with a desired characteristic were greatly enhanced by serving the female with a male exhibiting the desired characteristic (Gen. 31:10-12). It is shown below that this limited knowledge was sufficient to achieve the desired result. Jacob had at his disposal, after the first year's breeding, an identified source of the recessive wild allele, the young black rams. Although there were only a few rams, they could serve a large number of ewes, many of which, although white, carried the recessive black gene, and hence would bear a number of black lambs.

Geneticists often point out the difference in breeding potential of males and females, the first almost unlimited, the second very restricted. Jacob's breeding programme was only restricted by the breeding rate of the females, although obviously he did not have the theoretical knowledge to forecast the numerical outcome. The purpose of the flock was to provide meat and wool, so many of the animals were slaughtered each year, to be replaced by the newborn. In the example given below, the older animals are slaughtered each year, both black and white sheep.

If it is assumed that Jacob used only the black males for breeding, but that the genotypes of the females were in the proportion of the first years breeding (7AA:4Aa:1aa), then the result of the second year breeding would be as follows:

From the ewes genotype (AA) 14 genotype lambs (Aa)

From the ewes genotype (Aa) 4 genotype lambs (Aa) and 4 genotype lambs (aa)

From the ewes genotype (aa) 2 genotype lambs (aa)

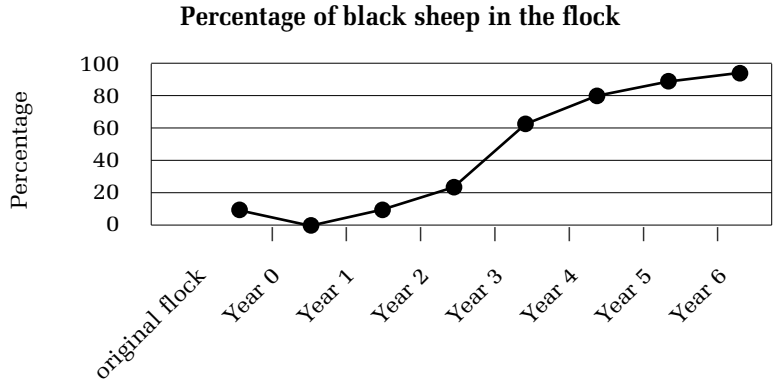
Thus after the second year of breeding, there are no lambs of the AA genotypes and the proportion of black lambs has increased.

At the start of the third year the proportion of genotype (AA), genotype (Aa) and genotype (aa) one year old ewes would be:

AA:Aa:aa = 0:18:6

One quarter of the new lambs are black and during each subsequent year of breeding from black rams the proportion of black sheep increases.

It is not known how many years the shepherds would breed from a ewe. If it is assumed that ewes were slaughtered after the first years breeding, then the proportion of lambs born in the different genotypes would become that of the flock in the next year. Modern shepherds have several years breeding from their chosen ewes. Jacob no doubt would use the same principle, keeping his black ewes for several years and culling the white ewes much younger. Obviously this makes the calculations more complex and the results predicted would depend very much on the assumptions.



The graph shows the results of this breeding strategy over a period of six years, using only black males, at the end of which 95% of the animals are black. By slaughtering some black sheep, presumably for his own household, Jacob could proudly tell Laban in Gen. 31:38 that he had not eaten sheep from Laban's flock. (It would have been impossible to abide by this rule before the birth of the first black lambs)

How Was Selective Breeding Achieved?

Genesis 30:38 states that the animals mated when they came to drink at the

troughs and when they were on heat. The supposed 'miracle' therefore occurred at the time of mating, when the ewe saw striped branches, not during the subsequent pregnancies. The modern 'old wives tale' interpretation of sights seen in pregnancy is not in fact referred to in the bible account. The branches were specifically erected when the ewes were on heat and ready to mate. What Jacob had to ensure was that the white rams did not mate with any of the ewes, and equally that the initially few black rams, produced by the first years free breeding, served all the ewes. A single ram in modern farming serves between thirty and fifty ewes, so Jacob would have no real problem in providing enough black rams to serve his flock, the problem lay in preventing the white rams getting at the ewes. There are two ways to attack the problem:

1. Castrate all the white rams, or more precisely kill all the adult rams, and castrate all the white male lambs, shortly after birth. In modern husbandry the majority of male lambs are so treated, to ensure faster growth, and a more manageable flock. It is possible that this practice was used in Jacob's time.

2. Prevent the adult white rams getting at the ewes, by building an enclosure using a fence made of "branches of poplar, almond and plane trees". In verse 40 the sheep are placed into two groups. How could this separation be maintained? Laban achieved it by placing the sheep three days journey apart, but the sheep in Jacob's groups could see each other (v.20). Building a fence to form an enclosure is the possible solution.

Westermann believed that the breeding narrative originated with herdsmen, and had not been of interest or fully understood by the writers. This paper proposes that it is more likely that working herdsmen would cut down branches of trees to build some form of enclosure than to carry out some magic spell.

Conclusions

It has been shown that contained in the sheep left by Laban in Jacob's keeping were sufficient recessive black genes to produce enough black rams to undertake a selective breeding programme. It is unnecessary to assume that such a procedure is a modern innovation. It has been shown that such a programme would produce a flock of predominantly black animals in a period of five years. In the period of six years in which the flock was in Jacob's keeping, Jacob would acquire most of Laban's flock. The biblical account emphasises that the significance of the tree branches was at the actual mating, rather than during the pregnancies. There is strong evidence that both Laban and Jacob had knowledge of the importance of inherited characteristics. The breeding programme would have involved the isolation of the white rams. This could be achieved by constructing a wooden pen, and the construction of this pen can be inferred from the biblical account.

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