



BLAD- Bovine Leukocyte Adhesion Deficiency

What is BLAD?

BLAD is a birth defect that is identified by persistent bacterial infections, delayed wound healing and stunted growth. These characteristics are caused by a deficiency of normally occurring proteins needed for white blood cells (or leukocytes), to travel to sights of infection and help fight them off. The disease has only been reported in Holstein cattle. Calves that are born with BLAD are generally poor doers but the symptoms may not be noticeable until the calf is a couple of weeks old. The calf can suffer several different illnesses such as recurrent bacterial infections, pneumonia, enteritis, diarrhoea or delayed wound healing and often die by four months of age. Animals that survive past this stage often have stunted growth and suffer from recurring skin infections, gastrointestinal problems and/or respiratory issues.

How is BLAD transmitted?

Like Brachyspina and CVM, BLAD is transmitted as an autosomal recessive, meaning that two copies of the abnormal gene (one from the dam and one from the sire) must be present in order for the trait to be expressed: this makes the animal homozygous for the undesirable allele. This means that a carrier animal does not exhibit the symptoms of BLAD but will transmit the gene to 50% of their offspring. Therefore:

- Mating a carrier (BL) animal and a non- carrier (BB) animal would be *expected* to result in 50% of the offspring being carriers and 50% being non carriers. Studies have been carried out to try and prove that carrier cows may have decreased mastitis resistance and lower birth weights, but it was found that carriers have no disadvantage to normal animals.

	B	L		
	BB	BL	B	50% non-carriers (BB)
	BB	BL	B	50% carriers (BL)

- Mating two carrier animals would be *expected* to result in 25% of the offspring being normal, 50% of the offspring being carriers and the final 25% being affected by BLAD. Consequently, breeders are strongly recommended to avoid mating two known carrier animals.

	B	L		
	BB	BL	B	25% non-carriers (BB)
	BL	LL	L	25% affected (LL)
				50% carriers (BL)

How is BLAD negative to the breed?

Since the immunity animals suffering BLAD is compromised, there are several financial implications such as reduced milk yield and increased veterinary costs. Luckily, the frequency of BLAD is reducing as all homozygous animals can be traced back to a single male ancestor and breeding from their gene pool is

greatly reduced. Most bulls sold in the UK are tested for BLAD, so it is easy to identify which are carriers of the disease and be cautious of using them.

CIT- Citrullinemia

What is CIT?

Bovine citrullinemia is a rare metabolic genetic disorder found in cattle. It is breed specific and CIT causes increased circulatory ammonia and associated neurological signs. Calves that are affected by CIT can be identified by symptoms such as loss of full body control, aimless wandering, blindness, head pressing, convulsions and death.

How is CIT transmitted?

Similar to BLAD and DUMPS, CIT is an autosomal recessive disease, meaning that two copies of the abnormal gene must be present in order for the trait to be expressed: this makes the animal homozygous for the undesirable allele. This means that a carrier animal does not exhibit the symptoms of CIT but will transmit the gene to 50% of their offspring. Therefore:

- Mating a carrier (NC) animal and a non-carrier (NN) animal would be *expected* to result in 50% of the offspring being carriers and 50% being non carriers.

	N	C		
	NN	NC	N	50% non-carriers (NN)
	NN	NC	N	50% carriers (NC)

- Mating two carrier animals would be *expected* to result in 25% of the offspring being normal, 50% of the offspring being carriers and the final 25% being affected by CIT. Consequently, breeders are strongly recommended to avoid mating two known carrier animals.

	N	C		
	NN	NC	N	25% non-carriers (NN)
	NC	CC	C	25% affected (CC)
				50% carriers (NC)

How is CIT negative to the breed?

Although calves can be born alive that suffer CIT, they often have to be euthanased at a young age due to neurological disorders. Most bulls sold in the UK are tested for CIT, so it is easy to identify which are carriers of the disease and be cautious of using them.

DUMPS- Deficiency of Uridine Monophosphate Synthase

What is DUMPS?

DUMPS is a disease of Holstein cattle which is characterised by lowered blood activity of enzyme uridine monophosphate synthase (UMPS). This then leads to embryonic death in the early stages of pregnancy. Luckily, the disease is fairly rare.

How is DUMPS transmitted?

DUMPS is transmitted as an autosomal recessive, meaning that two copies of the abnormal gene must be present in order for the trait to be expressed: this makes the animal homozygous for the undesirable allele. This means that a carrier animal does not exhibit the symptoms of DUMPS but will transmit the gene to 50% of their offspring. Therefore:

- Mating a carrier (Bb) animal and a non-carrier (BB) animal would be *expected* to result in 50% of the offspring being carriers and 50% being non carriers.

	D	P		
	DD	DP	D	50% non-carriers (DD)
	DD	DP	D	50% carriers (DP)

- Mating two carrier animals would be *expected* to result in 25% of the offspring being normal, 50% of the offspring being carriers and the final 25% being affected by DUMPS. Consequently, breeders are strongly recommended to avoid mating two known carrier animals.

	D	P		
	DD	DP	D	25% non-carriers (DD)
	DP	PP	P	25% affected (PP)
				50% carriers (DP)

How is DUMPS negative to the breed?

Since embryos are often reabsorbed during the first two months of gestation, fertility costs are increased due to more services per calving and longer calving intervals. Most bulls sold in the UK are tested for DUMPS, so it is easy to identify which are carriers of the disease and be cautious of using them.

Haplotypes

What are Haplotypes?

Haplotypes impact fertility and a haplotype is a group of DNA sequences at different locations on a chromosome that are transmitted together as a group. Three of the haplotypes that have been discovered in Holsteins are referred to as HH1, HH2 and HH3 and they operate independently of each other because they are situated on different chromosomes. This means that HH1 has no effect on HH2, or HH2 on HH3, etc.

How are Haplotypes transmitted?

In Holsteins, these three haplotypes each have carrier frequencies of 3-6% and some animals can carry two different haplotypes. If animal inherits the same haplotype from each parent (homozygous) then the animal will not survive birth: the haplotypes have never been discovered in their living animal in a homozygous form. There is a fairly high likelihood of an animal carrying at least one haplotype, but the probability of mating animals carrying the same haplotype is fairly low. Haplotypes follow a similar inheritance pattern as recessive genes. Therefore:

- Mating a carrier (CT) animal and a non- carrier (TT) animal would be *expected* to result in 50% of the offspring being carriers and 50% being non carriers.

	C		T	
CT	TT	T		50% non-carriers (TT)
CT	TT	T		50% carriers (CT)

- Mating two carrier animals would be *expected* to result in 25% of the offspring being normal, 50% of the offspring being carriers and the final 25% being affected by that haplotype. Consequently, breeders are strongly recommended to avoid mating two known carrier animals.

	C	T		
CC	CT	C	25% non-carriers (CC)	
CT	TT	T	25% affected (TT)	
			50% carriers (CT)	

How are Haplotypes negative to the breed?

Since haplotypes have a negative impact on fertility, it is important to be cautious of using bulls carrying certain haplotypes. However, many carrier bulls have a high genetic merit, and eliminating them from breeding policies can be detrimental to genetic progress in other areas. Therefore, it is important to instead be cautious of the carrier status of the females that a carrier bull is being mated too.

MF- Mulefoot (Syndactylism)

What is Mulefoot?

Mulefoot is a birth defect whereby the digits in calves are fused, causing the animal to be born with one or more feet with only one claw. The right front leg is the most commonly affected, followed by the left front leg. Affected calves can display varying levels of lameness, have a high step gait and may walk slowly. Calves can survive but require extra attention and many will succumb to hypothermia. Although the condition has been reported in several breeds, it is most common in the Holstein and Angus.

How is Mulefoot transmitted?

Mulefoot has been identified as a simple autosomal recessive trait with varying degrees of severity. The variation in gene transmission in Holstein cattle is clinically significant in that even if only one copy of the effected gene is inherited, some form of the disease may be present. However, generally classic cases of Mulefoot require two copies of the abnormal gene (one from the dam and one from the sire) must be present in order for the trait to be expressed: this makes the animal homozygous for the undesirable allele. Therefore:

- Mating a carrier (MF) animal and a non- carrier (MM) animal would be *expected* to result in 50% of the offspring being carriers and 50% being non carriers.

	M	F		
MM	MF	M	50% non-carriers (MM)	
MM	MF	M	50% carriers (MF)	

- Mating two carrier animals would be *expected* to result in 25% of the offspring being normal, 50% of the offspring being carriers and the final 25% being affected by Mulefoot. Consequently, breeders are strongly recommended to avoid mating two known carrier animals.

	M	F		
MM	MF	M		25% non-carriers (MM)
MF	FF	F		25% affected (FF)
				50% carriers (MF)

How is Mulefoot negative to the breed?

Mulefoot is not a lethal condition and although affected animals have locomotive problems, they can live to maturity. Most bulls sold in the UK are tested for Mulefoot, so it is easy to identify which are carriers of the disease and be cautious of using them.

Myoclonus

What is Myoclonus?

Myoclonus is a rare birth defect found in Hereford and Holstein cattle. Although newborn calves are often bright, alert and responsive, they also display several neurological signs. These signs include jerking of the whole body, abnormal sensitivity to touch or pain and rolling eyes.

Studies have shown that Myoclonus in calves is associated with a deficiency of inhibitory glycine receptors in the brain stem and spinal cord.

How is Myoclonus transmitted?

Myoclonus is an autosomal recessively inherited defect meaning that two copies of the abnormal gene (one from the dam and one from the sire) must be present in order for the trait to be expressed: this makes the animal homozygous for the undesirable allele. This means that a carrier animal does not exhibit the symptoms of Myoclonus but will transmit the gene to 50% of their offspring. Therefore:

- Mating a carrier animal and a non-carrier animal would be *expected* to result in 50% of the offspring being carriers and 50% being non-carriers.
- Mating two carrier animals would be *expected* to result in 25% of the offspring being normal, 50% of the offspring being carriers and the final 25% being affected by Myoclonus. Consequently, breeders are strongly recommended to avoid mating two known carrier animals.

How is Myoclonus negative to the breed?

Although affected calves can be born alive, very few live past a couple of weeks due to the severity of the problem. Most bulls sold in the UK are tested for Myoclonus, so it is easy to identify which are carriers of the disease and be cautious of using them.

Protoporphyrin

What is Protoporphyrin?

Protoporphyrin was first reported in South African Shorthorn cattle but most cases have since been reported in Holstein cattle, and it probably affects all meat producing animals. Affected animals display a reddish brown discolouration of the teeth, bones and urine at birth and these persist for life. If teeth, bones and urine are exposed to near- ultra violet light, they fluoresce pink. Affected animals can also develop skin lesions when exposed to sunlight. This means that animals that are not protected from sunlight become less thrifty.

How is Protoporphyrin transmitted?

Protoporphyrin is an autosomal recessively inherited defect meaning that two copies of the abnormal gene (one from the dam and one from the sire) must be present in order for the trait to be expressed: this makes the animal homozygous for the undesirable allele. This means that a carrier animal does not exhibit the symptoms of Protoporphyrin but will transmit the gene to 50% of their offspring. Therefore:

- Mating a carrier animal and a non- carrier animal would be *expected* to result in 50% of the offspring being carriers and 50% being non carriers.
- Mating two carrier animals would be *expected* to result in 25% of the offspring being normal, 50% of the offspring being carriers and the final 25% being affected by Protoporphyrin. Consequently, breeders are strongly recommended to avoid mating two known carrier animals.

How is Protoporphyrin negative to the breed?

Morbidity of affected animals can be controlled by keeping them indoors and out of direct sunlight. However, prevention is recommended and since many bulls sold in the UK are tested for Protoporphyrin, it is easy to identify which are carriers of the disease and be cautious of using them.

SMA- Spinal Muscular Atrophy

What is SMA?

SMA is a neurological disorder which promotes locomotion difficulties in young calves. These difficulties can then lead to partial paralysis of the limbs. These problems are a result of the degeneration and loss of motor neurons in the spinal cord as well as increased swelling/ abscesses of remaining motor neurons. Although many affected calves can appear normal and bright with a good suckling reflex at birth and even for a couple of weeks, the course of the disease is progressive and the calves become progressively weaker and all limbs can then become affected. Death is often the consequence, usually due to respiratory failure.

How is SMA transmitted?

SMA is an autosomal recessively inherited defect and is most prolific in the Brown Swiss breed. This means that two copies of the abnormal gene (one from the dam and one from the sire) must be present in order for the trait to be expressed: this makes the animal homozygous for the undesirable allele. This means that a carrier animal does not exhibit the symptoms of SMA but will transmit the gene to 50% of their offspring. Therefore:

- Mating a carrier animal and a non-carrier animal would be *expected* to result in 50% of the offspring being carriers and 50% being non-carriers. If a carrier cow is mated with a non-carrier bull (or vice versa) then SMA would not be responsible for locomotive problems.
- Mating two carrier animals would be *expected* to result in 25% of the offspring being normal, 50% of the offspring being carriers and the final 25% being affected by SMA. Consequently, breeders are strongly recommended to avoid mating two known carrier animals.

How is SMA negative to the breed?

Although affected calves can be born alive, very few live past a couple of weeks due to problems linked to locomotion and respiratory issues. Most bulls sold in the UK are tested for SMA, so it is easy to identify which are carriers of the disease and be cautious of using them.

Polled

What is polled?

Polled/ hornless cattle are preferred over horned cattle, and many farmers dehorn animals when they are young. Now, genetic selection is playing an important part to breed for naturally polled animals.

How is polled transmitted?

Unlike many other characteristics (e.g. CVM, Brachyspina, BLAD and DUMPS) that are controlled by a single gene, the polled gene has a dominant mode of expression rather than a recessive mode. This means that all animals that carry either one or two copies of the polled allele will be polled, so all horned animals must not carry the gene at all.

If an animal is DNA tested and found to carry two copies of the polled gene (POS), then 100% of its progeny will be polled, regardless of the status of the animal it is mated with. If an animal is visually polled (but hasn't been tested) then they will be a carrier of at least one copy of the polled gene and will be recorded as POC.

Animals that carry one copy of the polled gene would normally produce 50% of their progeny without horns. When two polled animals are mated together then about 75% of the resulting progeny will be polled if each mate just carried one copy of the gene, but this would reach 100% polled if either parent carried two copies of the polled gene.

Animals that are horned cannot transmit the polled gene and if two such animals are mated, none of the progeny will be polled.

Since the polled gene is dominant over the horned gene, the use of polled sires results in at least 50% of their progeny being polled. This has helped to speed up the increase of polled animals and select for genetically improved polled animals.

Coat Colour

Coat Colour Genetics

Although coat colour is simple to determine visually, the genetics behind it are complex with many possible genotypes determining the animal's appearance.

On the Holstein genome, there are two different locations that influence coat colour. One of these locations affects recessive red coat colour and the black/red colour form, whilst the other affects a dominant red colour. Recessive red is the most common form of red coat colour in Holstein cattle, but it is located at a different part of the genome than dominant red (they are different conditions that both affect the coat colour trait).

Recessive Red and Black/Red

There are four known forms of the gene at the recessive red location. There are two copies of the gene (one from sire and one from dam) that interact with each other depending on the forms present to produce colour patterns.

- Allele E^D (dominant form) codes for black and white coat colour
- Allele E^{BR} (black/red form) codes for black/red condition
- Allele E^+ (wild type form) codes for red and white coat colour
- Allele e (recessive form) codes for red and white coat colour

At the recessive red location, E^D dominates so animals with at least one copy of the E^D form of the gene will be black and white regardless of the other copy (unless altered by the dominant red gene).

Animals which have at least one copy of the E^{BR} form of the gene (and no dominant E^D) have the black/red condition and are usually born red and turn black over time, sometimes retaining some red colouring around the nose, ears and topline.

The wild type form is the most recently identified and is similar in effect to the recessive form of the gene. The most common type of red and white appearance is a result of two copies of the wild type or two copies of recessive, or one wild type and one recessive.

Dominant Red

Dominant red is a more recently reported trait which is completely independent of recessive red and was previously known as variant red. The dominant red trait follows a similar inheritance pattern of other dominant traits such as polled, and the dominant form (D) of the gene will also dominate over recessive red. This means that an animal is expected to be black and white due to the recessive red part of the genome, will be red and white if it has at least one copy of the D form of the dominant gene. The transmission of dominant red typically resonates as:

Parent Genotype	Progeny Appearance	Progeny Genotype
DD x DD	All red & white	All DD
DD x Dd	All red & white	50% DD & 50% Dd
DD x dd	All red & white	All Dd
Dd x Dd	75% red & white, 25% black & white	50% Dd, 25% DD, 25% dd
Dd x dd	50% red & white, 50% black & white	50% Dd & 50% dd
dd x dd	All black & white	All dd

Milk Components

Milk Components

Milk is made up of energy, water, carbohydrates, fat, protein, vitamins, minerals and enzymes. Milk protein consists of about 82% casein and 18% whey and they offer health benefits and improve cheese yield. Herds that carry dominant traits for favourable milk proteins are increasing in value for breeding and human nutrition.

Kappa Casein

Kappa casein is one of the major milk proteins comprising 14.5% of all caseins and 12% of all milk proteins. Kappa casein is a key protein in the cheese making process because the Kappa casein variant of the milk influences the renneting time and curd firmness. The cheese production properties of milk are better if the renneting time is short and the curd is firm. There are several variants of Kappa casein in the cattle population, and the percentage of Kappa casein not only varies between breed but also between individual animals depending on their genotype.

There are three possible gene combinations in a cow for Kappa casein:

- BB: preferred genotype for milk/ cheese production
- AB: intermediate for cheese production
- AA: least favoured genotype for milk production

Studies have found that cheese yield can be greatly improved with BB milk compared to AA milk and the renneting time is shorter.

Beta Casein (A2 Milk)

Several forms of Beta casein are present in cows milk depending on the cows genetic make up and Beta casein is 30% of the total protein content of cows milk. Two of these Beta caseins are A1 and A2. Neither the A1 or the A2 variant appears to be dominant so transmission is usually equal. Therefore,

- A1/A1 cows will only produce A1 Beta casein
- A2/A2 cows will only produce A2 Beta casein
- A1/A2 cows will likely produce milk with equal amounts of A1 and A2 Beta casein

A2 milk was the original Beta casein found in milk, and it wasn't until natural mutations occurred that A1 was introduced. Milk containing mainly A2 proteins are often said to be better for allergies such as gut, skin, rashes and hayfever compared to mainly A1 milk. Holstein cows generally have more A1 protein in their milk whilst breeds such as Guernsey and Jersey have more A2 proteins in their milk.

Beta Lactoglobulin

Beta lactoglobulin is the major whey protein found in cows milk, making up 59% of all whey proteins and 10% of total milk proteins. Beta lactoglobulin can be found in three forms:

- AA is considered the most favourable for milk and protein yield, but least favourable for fat yield
- AB is intermediate
- BB is least favourable for protein yield, but most favourable for fat content (better for cheese making)

ABCG2 Gene Mutation

The ABCG2 gene is linked to milk production and content.

- AA lower protein yield and concentration
- AC intermediate
- CC highest protein yield and concentration