

Livestock Judging Basic Genetics for Swine, Beef, and Sheep

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May 2010



Genetic Terminology

- Heredity – a study of description of genes passed from one generation to the next through reproduction. The heredity of an individual would be the genes received from the sire and the dam in reproduction.
- Heritability – The degree in which heredity influences a particular trait.

Genetic Terminology

- Heterosis – The tendency of the offspring of a cross to perform better than average of their parents.
- Heterozygous- An animal whose genotype for a particular trait or pair of genes consists of unlike genes. Ex... Aa

Genetic Terminology

- Homozygous – An animal whose genotype for a particular trait or pair of genes consists of like genes. Ex... AA or aa
- Genotype – The genetic makeup of an animal. A listing of genes carried by the animal, for one or several traits.

Genetic Terminology

- Phenotype – The characteristics that an animal shows or demonstrates. Includes both appearance and performance characteristics.
- Recessive – The tendency for a gene to be over shadowed by its partner in its influence on traits, after conception occurs and genes exist in pairs. Ex.. aa

Genetic Terminology

- Dominant – The tendency of one gene to exert its influence over its partner after conception occurs and gene exists in pairs, There are varying degrees of dominance, from partial to complete over-dominance.
- Breeding Value – The sum of gene effects of a breeding animal as measured by the performance of its progeny.

Genetic Examples

- A Homozygous recessive animal for a trait is mated with a Heterozygous animal for the same trait. What is the possible outcome of the offspring.
- Answer: Heterozygous animals and homozygous recessive animals.

	a	a
A	Aa	Aa
a	aa	aa

Swine Genetic Disorder



- The swine industry deals with the stress gene. In most purebred pedigrees this trait is selected against and not allowed in the breed.
- Example: Duroc, Landrace, Yorkshire, and Hampshire must be stress gene negative (or free of the gene). Stress Positive or Stress Carriers are not classified as purebreds.

Some Breeds Must Be Stress Free (NN Stress Negative)



Some Breeds Allow the Stress Gene

- Ex... Spot



NN Stress Negative



Nn Stress Carrier

Stress Gene (PSS)

- The porcine stress syndrome (PSS) gene is found to cause malignant hyperthermia (heat shock) when pigs are exposed to environmental stressors. This gene is commonly referred to as the halothane gene, because the PSS condition can be triggered by exposing pigs to the anesthetic, halothane gas.

Stress Gene Classification

- The PSS condition is an inherited disorder in swine. Inheritance of the PSS gene is at a single locus and there are two alleles, one dominant (N) and one recessive (n). There are three possible genotypes: homozygous recessive (nn), heterozygous or carriers (Nn) and homozygous normal (NN). Swine inheriting the n allele are more sensitive to stress. Pigs that are homozygous recessive (nn) are called PSS homozygous.

Stress Gene Classification

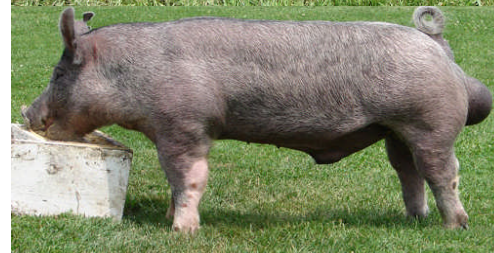
- **Stress Gene Negative** – free of the stress gene. Ex.. NN
- **Stress Gene Carrier** – contains one gene that is normal and one gene that has the stress gene. Ex... Nn
- **Stress Gene Positive** – contains two genes that contain the stress gene. Ex.. nn



NN



Nn



nn

Stress Gene Mating

Parent A	Parent B	Progeny Genotypes
NN	NN	100% NN negative
NN	Nn	50% NN negative, 50% Nn carrier
NN	nn	100% Nn carrier
Nn	Nn	50% Nn carrier, 25% NN negative, 25% nn positive
Nn	nn	50% Nn carrier, 50% nn positive
nn	nn	100% nn positive

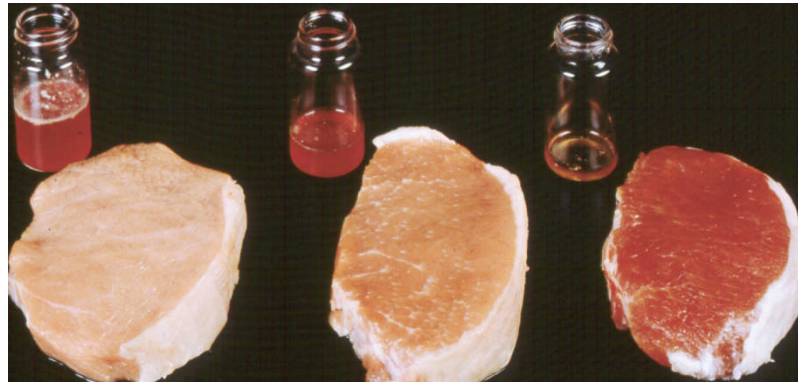
Problems with the Stress Gene

- Handling stress carrier and positive animals may result in death. Stress gene swine cannot handle extreme environmental changes.
- Stress gene swine may not be the best mothers. Creating additional difficulties in breeding, farrowing, litter size and milking.

Problems with the Stress Gene

- Stress gene animals may not be as vigorous in fighting infections, diseases, sickness, etc..
- Stress gene animals may turn blue, purple, or pink under environmental stress. When “stressing out” the animal may tighten their muscles and walk stiff legged. Sometimes they may shake and make loud noises.

PSE Pork



- Pigs carrying the PSS gene are more prone to producing pale, soft and exudative (PSE) pork, which is not only unattractive to consumers because of its unappealing greyish, soft and watery appearance, but is also less suitable for further processing because of its low water-holding capacity.

PSE Pork

- PSS homozygous pigs are more prone to developing PSE pork after slaughter than PSS carriers (Nn), which are more prone than normal pigs (NN).

Benefits of the Stress Gene

- The stress gene was used to increase muscling and leanness.
- Stress positive animals eat less feed but still gain extreme lean muscle.
- Research states that stress gene carriers or positive animals have 2-4% more muscle and leanness.

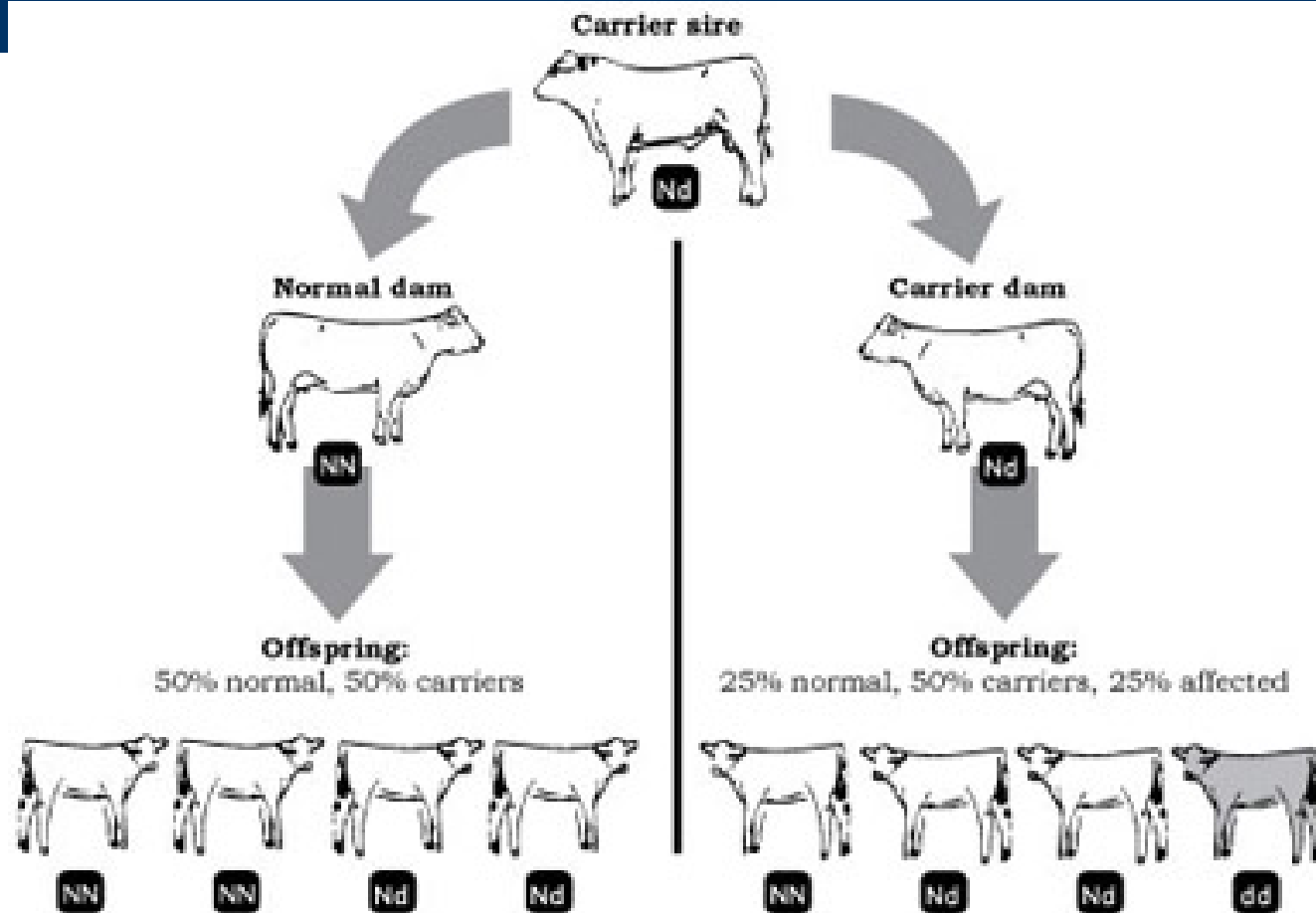
Elimination of the Stress Gene

- It is still recommended to limit or eliminate the stress gene in most breeding herds.
- The problems are far greater than the benefits.

Cattle Genetic Disorders

- The most common genetic test for cattle is PHA and TH. Additional test for NH and AM are common in most beef breeds.
- Genetic testing is done to reduce birth defects and abnormalities.

Cattle Genetic Disorders



Genetic Abnormalities By Breed

Genetic Abnormalities by Beef Breed Associations

Genetic Abnormality	Primary Breed(s) of Incidence	Lethal or Nonlethal	Mode of Inheritance
Arthrogyriposis multiplex (AM, or "Curly Calf Syndrome")	<u>Angus</u>	Lethal	Simple recessive
Beta (β)-Mannosidosis	<u>Salers</u>	Lethal	Simple recessive
Fawn Calf Syndrome (FCS)	<u>Angus</u>	Nonlethal	Presumably simple recessive
Neuropathic hydrocephalus (NH)	<u>Angus</u>	Lethal	Simple recessive
Hypotrichosis (hairless calf)	<u>Hereford</u>	Nonlethal	Simple recessive
Idiopathic epilepsy (IE)	<u>Hereford</u>	Nonlethal	Simple recessive
Osteopetrosis	<u>Angus & Red Angus</u>	Lethal	Simple recessive
Protoporphyrria	<u>Limousin</u>	Nonlethal	Simple recessive
Pulmonary hypoplasia & anasarca (PHA)	<u>Maine-Anjou & Shorthorn</u>	Lethal	Simple recessive
Tibial hemimelia (TH)	<u>Shorthorn & Maine-Anjou</u>	Lethal	Simple recessive

PHA

- PHA – Pulmonary Hypoplasia
- Most common in Maine-Anjou, Chianina, Shorthorn, and Crossbred breeds of beef cattle.
- “Pulmonary” refers to the lungs, and “Hypoplasia” means incomplete formation; thus “Pulmonary Hypoplasia” means incomplete formation of the lungs. “Anasarca” means a general accumulation of serum fluids in various tissues and body cavities; thus anasarca results in swelling and a swollen appearance.

PHA

- In order to be PHA-affected, a calf must inherit a PHA gene from both its sire and dam. Since the PHA gene is recessive, the lethal form of this condition is only expressed when the calf is homozygous for the PHA gene. PHA-affected calves are either aborted or stillborn. Because of the anasarca that is associated with this condition, the PHA-affected calf may also swell tremendously with fluid, making delivery difficult and potentially endangering the life of the cow.

Calf Born with PHA Defect



Maine calf with PHA. Notice the huge size of the calf and the swollen appearance.

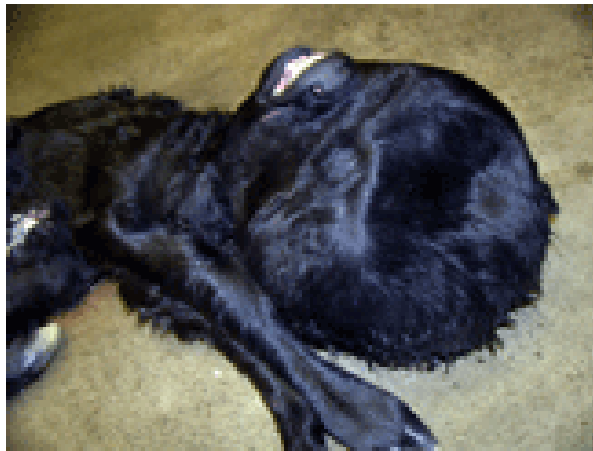
NH

- NH – Neuropathic Hydrocephalus “water head”
- NH is a recessive defect just as the previously identified disorder arthrogryposis multiplex (AM) is.
- NH would be described in a similar way to how AM has been described by the Angus association. If an animal is homozygous for the normal variant (called an allele) they are referred to as NH-free (NHF), indicating that they have been tested for the causative mutation and been found "free" of the mutation.

NH

- If an individual is found to be heterozygous, or a "carrier" for the mutation--meaning they possess one normal allele and one mutant allele--they are referred to as an NH-carrier (NHC).
- Although affected calves are rarely tested, they would be homozygous for the mutation and referred to as NH-affected (NHA).

Calf Born with the NH Defect



University of Illinois

Neuropathic hydrocephalus (NH):
small body, large head, short face, cleft palate
*Photo courtesy of David Steffen,
University of Nebraska*

TH

- TH – Tibial Hemimelia
- TH is a disorder of multiple congenital defects seen in calves. Translated, the name refers to absence of all or part of the tibia (tibial = the bone between the knee and ankle in humans or the stifle and hock in cattle and hemimelia = absence of all or part of a limb). But TH encompasses more defects than the name implies. TH is lethal, as the calf may be born dead, but if not dead the condition is incompatible with life.

TH

- These calves have large abdominal hernias (weakening of the abdominal muscles that allows intestinal contents to bulge out), twisted legs sometimes with absent or deformed bones.

Calves Born with TH Defect



Shorthorn calf with TH, large abdominal hernia and the twisted back legs. Notice the hoof of the top leg is backward from its normal position.



Shorthorn calf with TH, large abdominal hernia and the twisted back legs.

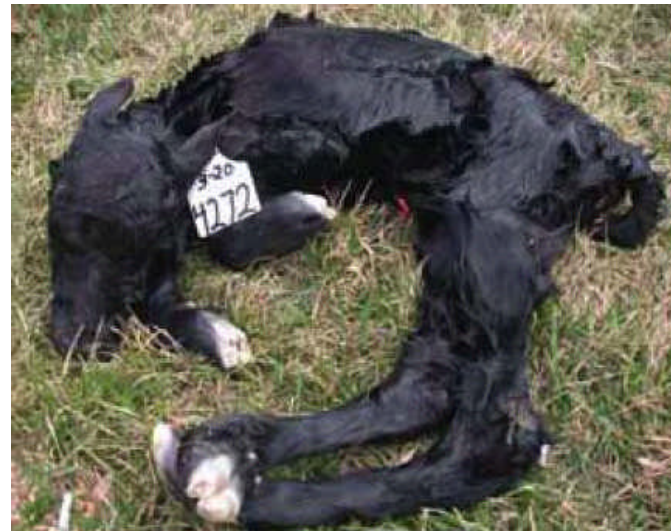
AM

- **AM – Arthrogryposis Multiple**
- AM was recognized as a genetic defect on September 16, 2008. Calves are born dead or die shortly after birth. The spine and legs appear crooked or twisted and the joints of the legs are often fixed in position. Front legs are contracted and rear limbs may be contracted or extended. Calves are small and appear thin due to limited muscle development. There may be a cleft affecting the nose or palate.

AM

- AM is caused by a recessive mutation on a single cattle chromosome. Cattle that are homozygous for the mutated gene will exhibit AM.

Calf born with AM Defect



Arthrogyryposis multiplex (AM)
*Photo courtesy of David Steffen,
University of Nebraska*

OS

- OS - Osteopetrosis
- Osteopetrosis (OS) or “marble bone disease” has been identified in Angus cattle dating back to the 1960's. This genetic defect is characterized by an increase in bone density and is known to be linked to a specific mutated gene that only recently can be identified through a DNA test. MMI Genomics (MMIG) is now offering this DNA test that will determine if an animal is a carrier or free of the genetic defect.

Calf Born with Osteopetrosis Defect



Osteopetrosis:

short lower jaw

*Photo courtesy of David Steffen,
University of Nebraska*

FCS

- FCS – Fawn Calf Syndrome
- Fawn calf syndrome is an autosomal recessive disorder of Angus and Angus cross cattle that has been extensively studied in Australia (parental verification, physical exam, necropsy, extensive pedigree analysis and breeding trials) that traces to US genetics. They are currently involved in the "gene hunt" and looking for samples.

FCS

- There is phenotypic variability in the calves. The calves are born with muscle contractures of the legs (which actually seem to improve with age); some have curvature of the spine, some die at or near birth but they can go on and reproduce - they always have poor muscling

Calf Born with FCS Defect



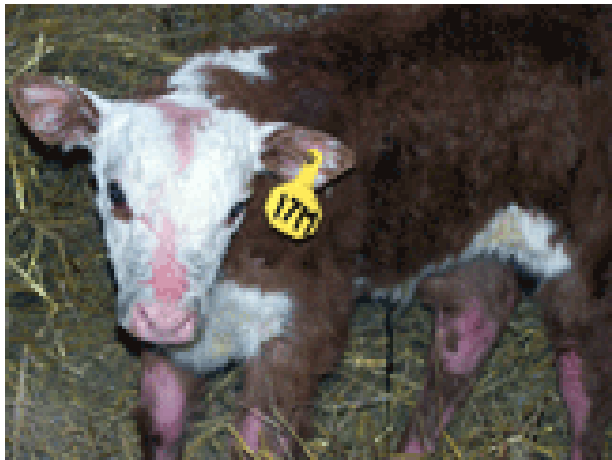
Fawn calf syndrome (FCS)

Photo courtesy of Photobucket.com

Hypotrichosis

- At least 13 types of **hypotrichosis** have been described in cattle, affecting Angus; Ayrshire; Brangus; Holstein-Friesian; Hereford; polled Hereford; Guernsey; Gelbvieh; Jersey; and Normandy-Maine, Anjou-Charolais, and Simmental crosses. Most have autosomal recessive or sex-linked modes of inheritance. Associated defects include failure of horn development, hypophyseal hypoplasia, macroglossia, dental anomalies, abnormal coat coloration, and death (lethal hypotrichosis).

Calf Born with Hypotrichosis Defect



Hypotrichosis:

hairless calf

*Photo courtesy of Jonathan Beever,
University of Illinois*

Protoporphyria

- Most cattle breeds have a genetic defect caused by a recessive gene mutation.
- In the Limousin breed there is a condition called protoporphyria caused by a defective gene.
- In its normal form the gene is responsible for the formation of the enzyme ferrochelatase which is involved in the combination of iron and protoporphorous to form haem, a component of haemoglobin.
- If two defective genes are present (homozygous defective) the animal is likely to exhibit protoporphyria.

Protoporphyrin

- Calves suffering with the defect have a very acute form of photosensitisation. The result is hair loss and/or development of ulcers on areas exposed to sunlight e.g., the ears, nose, udder and along the midline. As a result of the chronic inflammation of the skin some affected animals fail to thrive and are destroyed or sold to slaughter before finishing. Some affected animals recover, mature and will breed.

Calf Born with Protoporphyrria Defect



Protoporphyrria

*Photo by Kent Andersen,
North American Limousin Foundation*

Additional Genetic Terminology

- Polled – Genetic trait for having horns.
- Genetic Coloration – homozygous black = BB can be represented with a black cow. Bb can represent a carrier but black colored. While bb can represent a red cow.

Sheep Genetic Disorders

- Sheep genetic testing is performed in order to reduce birth defects, and prevent disease such as scrapies.
- In most cases blood tests are drawn before breeding the dam and sire.
- RRNN or QRNN

Sheep Genetic Disorders

- Scrapies
- Spider Syndrome
- Entropion (inverted eyelid)
- Jaw Defects

Scrapies

- **Scrapie** –Scrapie is a fatal disease affecting the central nervous system of sheep and goats. The cause of Scapie is a prion, that alters normal host proteins in the brain and spinal cord to cause disease.



Scrapies

- ***How is it transmitted?***

Scrapie susceptibility is an inheritable trait. Black faced breeds are particularly susceptible to scrapie. The scrapie prion can be transmitted thru direct contact with infected sheep. When a scrapie positive female gives birth, the offspring may have inherited the protein, or it may have contact with the proteins during birthing, or the offspring could pick it up from the environment if it is contaminated with scrapie protein.

Strapies Testing

- QQ = is not resistant to getting scrapies.
- QR = is a carrier but will be resistant to getting scrapies.
- RR = is resistant to getting scrapies.

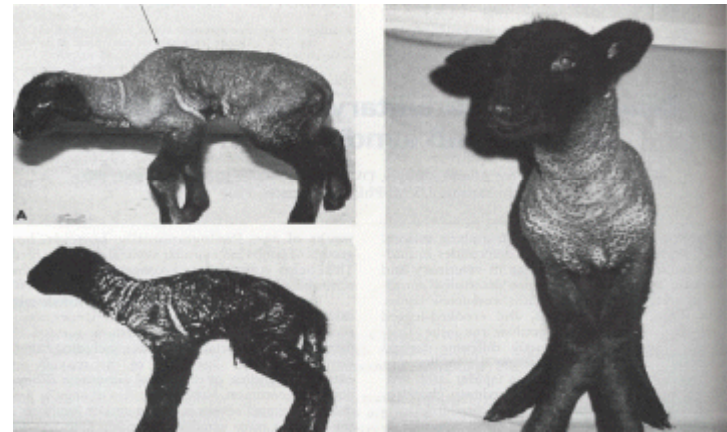
Spider Lamb Syndrome



- **Spider Lamb Syndrome** (SLS) or ovine hereditary chondrodysplasia is a genetic disorder causing skeletal deformities in young lambs. These defects commonly include abnormally long, bent limbs, twisted spines, shallow bodies, flattened rib cages, and long necks. The syndrome is inherited as a genetic recessive disorder meaning that affected lambs must inherit the mutation from both their parents.

Spider Lamb Syndrome

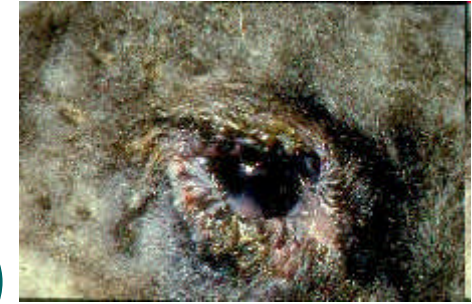
- Because of this inheritance pattern, the identification of genetic carriers of SLS has been difficult without the use of progeny testing. The presence of SLS in several breeds has prompted breeders to divide pedigrees into two categories, "gray-pedigreed" animals having ancestors that have produced spider lambs, and "white-pedigreed" animals having ancestors that have never produced affected lambs.



Spider Syndrome Testing

- NN = clean for spider syndrome
- NS = carrier for spider syndrome
- SS = is a spider and will not survive.

Entropion (inverted eyelid)



- **Inverted eyelids:** Inverted eyelid (entropion) is widespread among most breeds of sheep. This trait is highly heritable. Inverted eyelids are a "turning in" of the margin of the eyelid and therefore bringing the eyelashes into direct contact with the cornea. This contact creates an irritation, making it necessary for the animal to blink constantly. As the animal blinks, it is compounding the problem by scraping the eyelashes across a more extensive area of the eye. This extreme irritation if left unattended, can eventually cause blindness. The condition may be noted at birth and treated at that time.



Entropion (inverted eyelid)

- Entropion should never be left to take care of itself. If left untreated, the condition could cause sore watery eyes, infection, ulcers on the cornea and even blindness. Entropion condition requires surgical correction by a veterinarian. One method of treating this condition is to clip a metal suture to the center of the affected eyelid. Gather enough skin under the clip in a vertical direction to hold the lid away from the eye. The clip can be left in place for several days. Mark the affected lambs and do not allow them to enter the breeding flock.

Jaw Defects

- **Jaw defects** Jaw defects are present in almost all breeds of sheep and are associated with failure of the incisor teeth to properly meet the dental pad. A jaw is undershot if the incisor teeth extend forward past the dental pad; it is overshot if the teeth hit in back of the dental pad (this condition is known as parrot mouth). Cull sheep with either of these genetic defects. If the sire and dam can be identified, remove them from the flock.

Underbite



- **Underbite:** (undershot, reverse scissors bite, prognathism)
In this condition the lower jaw is longer than the upper jaw. If the upper and lower jaw meets each other edge to edge, the bite is referred to as an even or level bite. If your lamb has either an overbite or an underbite, it will not be able to properly nurse, get enough nutrition, or even eat from the creep feeder with the other lambs as seen below.

Overbite



- **Overbite:** (overshot, parrot mouth, class, overjet, mandibular branchygnathism)
In this condition the upper jaw is longer than the lower jaw. There is a gap between the upper and lower incisors when the mouth is closed. Some lambs that are born with an overbite might self-correct if the bite is no larger than the head of a wooden match. In most breeds of sheep the bites are "set" by the time a lamb is a few months old. An overshot bite will rarely improve after the lamb reaches maturity.