



Ruminants

Introduction

Sheep, goats and cattle are all even toed ungulates belonging to the order Artiodactyla, which also includes pigs, camels, llamas, giraffes and hippopotami. Sheep, goats, cattle and deer are all ruminants, in the sub-order ruminantia, belonging to the family Bovidae. They are closely related to the camelid species of South America.

a) SHEEP

The vast majority of sheep in the UK are kept for breeding and the production of lamb. However, some sheep breeds can be used for milk production, and these are more commonly found in Spain, Southern Europe and the Middle East, where sheep are frequently kept alongside goats. In Australia and New Zealand, the majority of sheep are kept for the production of fine wool.

Most adult female sheep weigh between 60 and 80kgs, although some breeds such as Soay may weigh as little as 40kgs.

Sheep are commonly used in research, in particular as alternatives to rabbits as producers of polyclonal antibodies. They have also been used for synthesising bioactive compounds in milk, and for studies on parturition, neonates and reproduction, as well as in studies on the prion diseases.

Breeds

There are over 70 different breeds of sheep in the UK. The hill and upland breeds (Scottish and Welsh mountain, Cheviot, Swaledale), generally have long-wool and are smaller in size than the lowland breeds, (Dorset, Southdown, Oxford). However, the vast majority of breeding ewes in the UK are cross-bred, with the commonest of these being the "mule", a cross between a hill breed ewe (Swaledale or Welsh mountain) and a Blue-faced Leicester ram. The mule ewes are then crossed with a terminal sire, such as a Suffolk, Texel or Charollais, to produce fast growing meaty lambs for slaughter.



Young Suffolk ram



Mule ewe and lamb

Biology

Skin and hair: Sheep are covered in wool, unlike other ruminants. They also secrete large amounts of lanolin (wool grease) from their sebaceous glands. Lanolin helps to waterproof the skin and coat, whilst the insulating properties of wool give the sheep excellent cold weather protection. Some breeds produce a very fine wool (ie the Merino from Spain and Australia), which is valuable in the manufacture of fine clothing. Other breeds have much coarser wool, which is more suitable for blankets and carpets.

Some breeds of sheep possess horns, whilst others are naturally hornless.

Digestive system: The digestive system of all ruminants is similar, and has developed to extract nutrients from plant material. They not possess canine teeth or upper incisors. Instead they have a hardened pad (the dental pad) against which the lower incisors bite. The tongue has a large dorsal swelling posteriorly, which makes visualization of the larynx difficult when trying to pass an endotracheal tube

All ruminants possess a 4-part stomach, the largest chamber of which is the rumen. A functioning rumen is essential to utilise the grasses that form their diet. The rumen is in effect a large fermentation chamber, which serves to break down the cellulose in plants and convert it into nutrients that can be absorbed and utilised by the goat.

Reproductive system: Sheep are seasonally polyoestrus, having a 17-day oestrus cycle, which starts during the autumn and finishes in late winter. However, there is some variation in the exact length of the breeding season between breeds, with hill and mountain breeds having shorter seasons than the lowland breeds. The Dorset has the longest breeding season of native British breeds - from approximately July to March. Most breeds are generally most fertile in October/November, to give lambing in March April.

The gestation length is normally 147 days (5 months). Ewes mated (tupped) on Guy Fawkes Day (5th Nov) should lamb on April Fools day (1st April). Ewe lambs may be bred in their first autumn at approximately 6-7 months of age, but more commonly will be run-through to be mated the following year at 18-19 months of age.

Artificial insemination is uncommon in sheep because the structure of the ewe's cervix makes it extremely difficult to catheterise. There is a technique for inseminating frozen semen directly into the uterine horns via laparoscopy, but this is a veterinary procedure and its use is limited for reasons of both cost and welfare. Embryo transfer is successful in sheep, but not usually economically viable.

Some normal biological values for sheep

Weight at birth	3-5kg
Adult weight	50-90 kg
Gestation period	147 days
Age at sexual maturity	5-8 months

Husbandry

Rearing: Lambs are normally born as singletons or twins. However, there are tremendous breed variations, with the mountain breeds having more singles than twins, whilst some of the more prolific lowland breeds may have a high incidence of triplets and even a few quads. Lambs normally remain on the ewe until weaning at 12-16 weeks of age, although some frequent breeding systems using Dorsets will wean the lambs at 6 weeks of age so that the dams can be re-bred more quickly. There are also a small number of flocks in the UK that milk ewes, for cheese and yoghurt production. Their lambs are usually weaned from the ewe at a few days of age, and reared on milk replacer for 6 weeks, as for dairy cows.

For experimental purposes, it may be necessary to caesarean derive and/or artificially rear lambs. Artificially reared lambs should be weaned at 4-5 weeks of age.

Housing: Sheep are well protected from extremes of cold and can survive well outdoors in the UK winter, providing food is available. However, the majority of sheep kept for research will be provided with some shelter in inclement weather.

If they are housed, sheep should be kept in groups. If they have to be kept singly for experimental reasons, then they should always be within sight, sound and smell of each other. Horned and polled sheep should generally not be mixed in the same pen for fear of bullying and injuries. If horned sheep are to be housed together, more space should be allowed.

Temperature and Humidity: Sheep are normally kept outdoors, where they will be exposed to ambient temperatures and humidities.

If kept indoors, sheep can easily become too hot and suffer from heat-stress during the UK summer, particularly if they have not been shorn. When kept indoors, the temperature should remain within the limits 10-24⁰C. Lambs will need to be kept warmer for the first few days of life, after which they will tolerate the same conditions as adults.

Ventilation: Good ventilation is essential in sheep housing, as high relative humidity can contribute to pneumonic disease. A dank smell, with cobwebs in the roof space indicates that there is little air movement in the building, which is an ideal environment for the development and spread of respiratory disease.

It is important that the ventilation system ensures good air circulation without creating draughts at animal level.

Stocking densities: The Home Office Code of Practice for the Housing and Care of Animals Used in Scientific Procedures gives the following guidance.

Goats and sheep bodyweight	Minimum floor area in m ² when housed in groups	Minimum floor area in m ² when housed singly	Minimum length of feed rack or trough per head in metres
< 35 kgs	1.3	2.0	0.35
> 35 kgs	1.9	2.8	0.35

Lighting: Ideally lighting should be natural, but in some indoor accommodation this may not be possible. If they are housed indoors, it is essential that they are exposed to seasonal fluctuations in day length if they are to be bred.

Feeding: Sheep are strict herbivores, predominantly eating grass. When close to lambing, ewes should also receive some supplementary feed in the form of cereal-based concentrates, to supply additional energy and protein. Note that sheep are very sensitive to the toxic effects of copper, which is found at background levels in all cereals. Care should therefore be exercised when feeding supplementary cereal feeds or minerals to sheep.

During the winter months, when there is insufficient grass, sheep will normally be fed conserved grass, in the form of hay or silage, or occasionally straw. They can also graze other crops, such as turnips or kale, over-winter.

Fresh water must be provided at all times. This may be from a trough or bowl drinker.

Water: Sheep prefer to drink flowing water and will not usually drink from dirty, static tanks. Although flowing water may be difficult to provide, it is essential that water tanks are regularly cleaned out.

Bedding: Sheep are usually bedded on straw, which also acts as environmental enrichment, as they spend time picking over the straw for the more tasty morsels. However, because of the consumption of at least some of the straw, there can be scientific reasons for sometimes keeping them on alternative bedding, such as wood shavings.

Routine tasks: Most lambs are castrated and tail docked by the application of rubber rings in the first week of life. Other routine tasks are navel spraying and ear tagging.

Adult sheep require shearing annually, usually in May or June. Internal and external parasites are very common problems in sheep, and routine treatments are required to control these.

Environmental enrichment: Providing satisfactory environmental enrichment for sheep is difficult. They are flock animals and it rare to find individuals separated from the remainder of the flock, unless they are sick. They can become disturbed if they do not have contact with other sheep, so always keep them in groups, or at least in pairs. They are nervous of humans, but can be trained, and may follow a handler, especially if they have food.

The provision of roughage is essential for their health and is also a source of environmental enrichment, as they can spend considerable time selecting and consuming it. Other forms of enrichment (balls, playthings), tend to be of limited value for sheep.

b) GOATS

Introduction

The most likely ancestor of the modern domestic goat (*Capra hircus*), is the Bezoar (*Capra aegagrus*), which is still found in the Middle East and Asia Minor.

Selection for milk, meat or skins has led to the development of several breeds, of which the Saanen, British Alpine, Anglo Nubian and Toggenburg are the commonest breeds in the UK. Most adult dairy goats weigh between 55 and 90kgs, although there is also a dwarf goat breed, the pygmy goat, which can weigh as little as 20kg.



Saanen female (doe)

Biology

Skin and hair: Goats are covered in hair, unlike sheep that have wool. However, some breeds, such as the Angora and Cashmere, have been developed specifically for fibre production (mohair and cashmere) and have much longer coats. Most goats possess horns and some also have beards and wattles. The tail is naturally short and stands up when the animal is alert. They have offensive smelling scent glands around the horns in both sexes, and also under the tail in the male.

Digestive system: As with all ruminants, goats do not possess canine teeth or upper incisors. Instead they have a hardened pad (the dental pad) against which the lower incisors bite. The tongue has a large dorsal swelling posteriorly, which makes visualization of the larynx difficult when trying to pass an endotracheal tube

All ruminants possess a 4-part stomach, the largest chamber of which is the rumen. They rely on a functioning rumen to utilise the grass and other plant material that form the diet. The rumen is in effect a large fermentation chamber, which serves to break down the cellulose in plants and convert it into nutrients that can be absorbed and utilised by the goat.

Reproductive system: Like sheep and deer, goats are seasonal breeders. Their breeding season extends from approximately September to March, during which time they will come into oestrus approximately every 21 days.

The onset of the breeding season is controlled by diminishing day length, as occurs in the autumn in the Northern hemisphere. It is possible to advance the breeding season by the use of hormones, or by artificially prolonging day-length over the winter months.

Both sexes become sexually mature at around 6 months of age, so female kids born in the spring may be mated in their first autumn, although most are not bred until they are 18 months old. Artificial insemination and embryo transfer techniques are both possible in goats.

The gestation length is 150 days, although this can vary by up to 5 days either way. The normal litter size is between 1 and 3 kids, although quads are sometimes seen. Pregnancy can be confirmed by blood or urine tests from about 30 days, or by ultra-sound scanning from about 50 days.

Cloudbursts: Some older goats may suffer from a form of pseudopregnancy, showing increased abdominal and udder swelling over a period of months. This is normally resolved by the eventual discharge of copious quantities of uterine fluid (the "cloudburst"), at or about the expected time of parturition. Such animals may well breed normally in future years.

Maiden milkers: Goats are also unusual in that some maidens will come into lactation without any prior pregnancy or parturition.

Some normal biological values for goats

Weight at birth	2-4 kg
Adult weight	50-90 kg
Gestation period	150 days
Age at sexual maturity	5-8 months

Husbandry

Housing: Goats are less well protected from extremes of cold than sheep, and dislike rain. They should always be provided with shelter and a dry, draught-free bed. An open fronted building will usually be sufficient, provided it backs into the prevailing wind.

Wherever practicable, goats should be group housed, or at least housed within sight of each other. However, horned and polled goats should generally not be mixed in the same pen for fear of bullying and injuries. If horned goats are to be housed together, more space should be allowed. Pens should be rectangular rather than square and the width of the pen should be not less than the length of the goat from nose to root of tail.

Goats are particularly agile and can leap over barriers several feet high, so all fences should be at least 4-5 feet.

Temperature and humidity: Goats are more heat tolerant than sheep, but are less able to stand extremes of cold. When housed indoors, the HO Code of Practice requires goats to be kept at temperatures of between 10-24⁰C and at a relative humidity of 45-65%.

Ventilation: If goats are held in controlled environment conditions, it is very important to maintain air flows of 15-20 air-changes/hour, as poor ventilation will soon result in a build up of airborne dust, microorganisms, water vapour and ammonia, all of which will be detrimental to their health and predispose to respiratory disease.

Stocking densities: The Home Office Code of Practice for the Housing and Care of Animals Used in Scientific Procedures gives the following guidance.

Goats and sheep bodyweight	Minimum floor area in m ² when housed in groups	Minimum floor area in m ² when housed singly	Minimum length of feed rack or trough per head in metres
< 35 kgs	1.3	2.0	0.35
> 35 kgs	1.9	2.8	0.35

Lighting: Goats are normally kept in natural daylight. If they are housed indoors, it is essential that they are exposed to seasonal fluctuations in day length if they are to be bred.

Feeding: Goats are strict herbivores, but are primarily browsing animals, (rather than grazing, as sheep and cattle). They are very inquisitive, and notorious for eating anything hanging at head height or above (washing), and will strip vegetation off trees to a considerable height. However, in the absence of trees, goats will graze and can be maintained on grass in paddocks. Notwithstanding their appetites for eating clothing, they are relatively fastidious, and will refuse food that has been soiled by faeces or urine. Feeding troughs must therefore be kept very clean and hayracks should be suspended well above the

floor. This not only prevents soiling of the hay, but also allows the goats to perform their natural, browsing behaviour.

During the winter months, conserved forage, such as hay or silage must be fed. Lactating goats can produce as much milk/kg bodyweight as dairy cows and therefore will also require supplementary concentrate feeds at times of peak lactation. Note that goats (like sheep) are very sensitive to the toxic effects of copper, and even relatively low levels of copper in concentrate rations may lead to poisoning and death. Commercial sheep feeds are formulated to be low in copper, and are therefore also suitable for goats, but be very careful about feeding other diets, such as those intended for cattle or pigs, which may have additional minerals.

Water: Goats are fussy drinkers and must be provided with ad-lib clean water at all times. Water bowls must be regularly cleaned out. Lactating goats can drink 10 or more litres of water daily.

Bedding: Most goats are bedded on deep straw. It is inevitable that they will consume some of this, but it is of little nutritional value. New straw should be added daily to keep the bed clean.

Disbudding: In order to facilitate future handling, most goat kids have their horn buds removed at about 4 days of age. If this procedure is delayed beyond the first week, there is a danger of incomplete removal and re-growth. This is a veterinary task as the technique must be carried out under general anaesthesia, because goat kids do not tolerate local anaesthetics very well. Alphaxalone (Alfaxan) or propofol are the anaesthetic agents of choice for this, although induction with isoflurane may also be considered.

Castration: Male kids are usually castrated at a few days of age, to avoid handling problems when they become mature. Castration is usually carried out at the same time as disbudding, under general anaesthesia.

Rearing: The majority of goats are kept for milk production, so kids are normally removed from the dam at about 4 days of age so the dam can be milked for human consumption. The kids are then reared on milk or milk-substitute from a bottle or bucket. These kids are then weaned at about 2 months of age.

Other: Like sheep, adult goats kept at pasture will require routine treatments for intestinal parasites and also preventive treatments for ectoparasites, such as flies and lice. They will also require attention to the feet and annual vaccinations against clostridial diseases.

Environmental enrichment: Goats are inquisitive animals and tend to be more independent than sheep. They normally live in groups, but will cope well if they have other species such as humans or sheep for companions. If disturbed, they will scatter, relying on their agility over difficult terrain to escape. This makes them impossible to drive. However, they can be led, and will usually follow a handler, especially if they have food. They frequently stand on their hind feet to explore, and can easily reach to a height of 2 metres, so this should be considered when suspending items near or above goat pens. Their curiosity causes them to lick or chew at any unusual material, which can lead to the ingestion of foreign objects and may be the cause of accidental poisoning or even electrocution from suspended electric cables.

Goats form a strong social hierarchy and the introduction of new members to a group may result in fighting. As many breeds are horned, this can lead to injuries. Males can also be aggressive during the breeding season.

The provision of a raised area in a pen or pasture is a useful environmental enrichment, as goats are natural climbers. Because of their natural inquisitiveness, goats will investigate objects such as toys or chains, particularly if these are suspended above head height. The provision of roughage above head height, to allow natural browsing behaviour, is also recommended. Because goats readily become accustomed to contact with humans, this should be encouraged during routine husbandry procedures and perhaps at other designated times.

c) CATTLE

Cattle are less commonly used for research in the UK, not least because of their large size and low fecundity. They are most frequently used for research into those ruminant infectious diseases that have human health significance, such as Tuberculosis, Salmonellosis, *E coli* O157 and Bovine Spongiform Encephalopathy (BSE), or for ruminant diseases that are internationally important, such as foot and mouth disease (FMD) and Bluetongue. The production of milk is a vital national resource, and research into the feeding of dairy cattle and the quality of milk and meat produced from cattle is also undertaken.

Breeds

Cattle are normally classed as either dairy or beef breeds. Over the last 30 years, the predominant dairy breed has become the Holstein Friesian, whilst other native breeds, such as Jersey and Guernsey, have become increasingly rare. Native beef breeds include Aberdeen Angus, and Hereford, but there are also many imported beef breeds, such as Charolais, Limousin and Simmental. Some breeds possess horns, whilst others are naturally hornless.

The value of the purebred Holstein Friesian male calf is low, and so once sufficient Friesian female calves have been born to fulfil the replacement requirements of the herd, the dairy cows are usually crossed with a beef breed bull to produce a more valuable calf.



Holstein Friesian cow



Hereford bull

Biology

The biology of cattle is generally very similar to that of sheep and goats, but they differ markedly in their reproductive cycle.

Reproduction: Unlike sheep and goats, cattle will breed throughout the year. They exhibit oestrus every 21 days, although this may sometimes be less obvious during the winter months. The gestation length of cattle is approximately 282 days (9 months), although there are slight breed variations. Young females (heifers) are normally mated (served) at about 15 months of age, so that they calve at 2 years. Service may be by bull, or more commonly in dairy herds by artificial insemination (AI) using frozen semen purchased from an AI centre. Embryo transfer (ET) is also used in some herds.

Ideally, following calving, cows will be re-mated 3 months into their lactation, so that they calve again 12 months later.

Rearing: Calves are usually born as singletons, although approx 5% may be twins. A calf will usually weigh 35–50 kgs at birth. The method of rearing will vary between breeds.

- With beef breeds, the calf will remain on the dam for up to 9 months
- With dairy breeds, the calf will remain on the dam for only 1-4 days. This ensures that it obtains the antibody-rich first milk (colostrum). It will then normally be reared on milk replacer fed from a bucket or a machine, until weaning at approximately 6 weeks of age.

For experimental purposes, calves are sometimes required to be “colostrum deprived”, when they must be removed from the dam at birth before sucking. This ensures that they have no passively acquired maternal antibodies. Calves may sometimes be required to be born “germ free”, so they can later be infected with organisms under study (“gnotobiotic”). These calves must be delivered by caesarean section and subsequently reared in an isolator.

It is very important that as well as milk, calves are given some fibre (hay) in their diet from an early age to promote the development of the rumen. The changeover from a milk-based diet to one that is based on cereal and fibre is a critical stage in the development of a calf. Routine tasks such as disbudding and castration are carried out under local anaesthesia by farm staff, or by a vet, within the first 10 weeks of life.

Husbandry

Housing: Cattle are generally very hardy and many breeds will out-winter in the UK with minimal protection, although they can cause significant damage to the pasture. Dairy breeds however, are normally housed during the winter months, in which case it is important that they are provided with a dry, draught-free bed.

Cattle are herd animals and should be group housed, or at least housed within sight of each other. However, horned and polled cattle should generally not be mixed in the same group for fear of bullying and injuries.

Temperature and humidity: When housed indoors, the HO Code of Practice requires goats to be kept at temperatures of between 10-24⁰C and at a relative humidity of 45-65%.

Ventilation: If cattle are held indoors, it is very important to maintain air flows of 15-20 air-changes/hour, as poor ventilation will soon result in a build up of airborne dust, microorganisms, water vapour and ammonia, all of which will be detrimental to their health and predispose to respiratory disease.

Stocking densities: The Home Office Code of Practice for the Housing and Care of Animals Used in Scientific Procedures gives the following guidance for cattle.

Cattle	Minimum floor area in m ² when housed in groups	Minimum floor area in m ² when housed singly	Minimum length of feed rack or trough per head in metres
< 60 kgs	1.5	2.2	0.3
60-100 kgs	1.6	2.4	0.3
100-150 kgs	1.9	2.8	0.35
150-200 kgs	2.4	3.6	0.4
200-400 kgs	3.8	5.7	0.55
> 400 kgs	5.3	8.0	0.65
Adult bull	-----	16	0.65

Feeding: Like sheep and goats, cattle are strict herbivores and spend many hours each day grazing and ruminating when at pasture.

During the winter months, conserved forage, such as hay or silage must be fed. Dairy cows will also require supplementary concentrate feedstuffs during lactation.

Water: Lactating dairy cows require vast quantities of water daily, and must be provided with ad-lib clean water at all times.

Bedding: Dairy cows may be bedded on a number of different materials, including straw, sand, and a variety of types of commercial matting. The cleanliness of the bedding and the concrete walk areas is critical in controlling diseases such as mastitis, and lameness.

Disbudding: Nearly all calves born with horn buds have these removed in the first few weeks of life. By law, this procedure must be carried out under anaesthesia. This is not a veterinary task if carried out using local anaesthesia.

Castration: Nearly all calves are castrated at a few days of age, to avoid handling problems when they become mature. Castration is usually carried out at the same time as disbudding, under local anaesthesia.

Rearing: Calves from dairy cows used for milk production, are normally removed from the mother at about 4 days of age. They are then reared on milk-substitute until weaning at about 6 weeks of age.

Environmental enrichment: Cattle are social animals that normally live in groups, and it rare to find individuals separated from the remainder, unless they are sick. They should not be housed singly. As with sheep, the provision of suitable environmental enrichment is difficult. The provision of other cattle for company together with adequate long-fibre roughage are important enrichments. Scratching posts are well used, and one of the best types is a rotating brush that grooms the coat.

Ruminants - Personal Safety

1) Handling and restraint

Cattle are not usually aggressive, unless they have young at foot. However, the large size of cattle (6-700kgs for an adult Holstein-Friesian cow), make them potentially very dangerous to restrain and handle. Horned ruminants are always potentially more dangerous. A restraining “crush” is necessary to be able to handle these animals safely.

Adult males (bulls, rams and billy goats) are always more aggressive than females, and should always be treated with caution. Adult bulls can be very dangerous animals and cause many human deaths every year.

Sheep are placid and generally speaking do not pose an injury threat to humans. To catch them, they should be corralled as a group into a confined space and then the individual restrained by placing an arm around its neck.



Sheep should not be caught or held by the fleece. To examine the underside of a sheep, they can be “cast” onto their sides or back.

Goats are often horned, which can be dangerous for the handler, but they are generally less nervous than sheep and can be caught quite easily with a little patience. Goats should not be caught or restrained by the horns, but by holding around the neck or with the hands either side of the head, behind the lower jaw. A soft collar around the neck of the goat may assist handling. Examination of the goat, including the feet and the udder, is usually performed in the standing position, as for a cow.

2) Zoonotic Diseases

A number of animal diseases are transmissible to humans. Collectively these are known as zoonoses. The important zoonoses that are transmissible between ruminants and man in the UK are:

- Contagious pustular dermatitis (Orf) – A viral skin disease of sheep and goats, also causing skin lesions in humans
- Ringworm – fungal skin condition of all ruminants, causing itchy skin lesions in humans
- Chlamydia (enzootic abortion) – A cause of abortion in sheep and goats which can cause abortion and potentially severe illness in women
- Toxoplasmosis – A cause of abortion in sheep and goats that may cause illness in humans
- Q Fever – A bacterial infection causing abortion in sheep and goats, and severe illness in humans
- Cryptosporidiosis – A protozoan parasite of all ruminants causing diarrhoea, mostly in children
- Campylobacter – A bacterial infection, often asymptomatic in ruminants but may cause food poisoning in humans
- *E. coli* O157 – Usually asymptomatic in ruminants but may cause food poisoning in humans
- Salmonellosis – severe systemic disease in ruminants and humans
- Anthrax – a fatal septicaemia in all ruminants and humans – very rare in the UK

NOTE: Sheep and goats can become infected with a number of agents that cause abortion and are transmissible to humans. **Women of child-bearing age (and especially pregnant women) should not therefore work with sheep at lambing times.**

Ruminants - Health and Disease

Biosecurity:

Ruminants are not included in Schedule 2 of ASPA, (except genetically altered sheep) and so may be purchased from any commercial source; direct from a farm; from a dealer; or even from a market. Such animals will often be of unknown health status, so it is a case of “*caveat emptor*” – let the buyer beware.

Cattle and sheep farms are generally much less disease conscious than pig or poultry farms. Most do not test for any diseases other than those that are compulsory (TB in cattle). Any health assurances should be viewed with suspicion.

Unfortunately sub-clinical infections can often become clinical if the animal is stressed, for instance by transport, or changes in the management or environment. These are exactly the stresses imposed on conventionally reared farm animals that are purchased for use in research. An additional stress will also occur if animals from different sources are mixed together. Then, the different pathogens that each is carrying will inter-act. The effects of this are normally additive, resulting in an outbreak of clinical disease in the group a few days after mixing.

Recognition of wellbeing, pain, suffering and distress

Behaviour: A healthy ruminant should normally be alert, inquisitive and interact with others in the group (normal social behaviour). However, it is normal for ruminants to spend a large part of each day lying down, ruminating. Chewing the cud is usually a reliable indicator of good health.

A sick ruminant may lie apart from the remainder of the group, or be reluctant to rise when approached, or lag behind when it is moved. Dullness, drooping ears, reluctance to rise, anorexia and separation from the group are all indicators of pain or distress. The rumen may also cease to contract, so they do not regurgitate a “cud”.

Sheep and cattle are not usually very vocal, and they tend to mask the signs of pain. However, when in pain, all ruminants will grate their molar teeth together, giving rise to a very distinctive noise, known as “teeth grinding”.

Body condition: Assess the condition of the animal. Is it well grown for its age? Does it have a healthy covering over the dorsal spines of the backbone? There are systems for body condition “scoring”, grading between 1 (emaciated) to 5 (obese). A condition score of 3 is considered optimal. Unfortunately, it is impossible to assess the body condition of sheep from a distance, because the thick covering of wool hides poor body condition. You always need to handle a sheep to assess its condition accurately.

Appearance of the coat: The coat should not show discolouration (blowfly strike in sheep) evidence of rubbing (scrapie in sheep/goats or lice in cattle) or biting (sheep scab or lice). Loss of wool in sheep can be due to many causes – external parasites, such as mange or blowfly strike are two of the commonest.

Gait and nervous symptoms: Lameness is common in both cattle and sheep, although for different reasons. In sheep it is often due to infection with the bacterium *Dichelobacter nodosus*, which causes the disease known as foot rot. In cattle, their additional weight and the amount of time spent on concrete, means that it is more usually due to trauma of the sole of the foot

There should be no abnormal nervous signs – body tremors, circling, blindness or head tilt etc. Sheep and goats are both subject to a large number of nervous conditions; infectious, parasitic and metabolic.

Respiratory system: When a ruminant is at rest, the respiratory movements should be hardly visible. If they are shallow and rapid or deep and laboured, then there is some degree of respiratory distress. This

could be due to pain or disease, or to a combination of both. Sheep are generally less commonly affected by respiratory disease than the other ruminants, which is probably a reflection that they are less commonly kept indoors.

Gastro-intestinal system: There should be no evidence of diarrhoea, which usually shows as staining of the hair or wool on the tail. Blood in the faeces may be due to excessive straining, or to some of the more virulent infections, such as gastro-intestinal worms or coccidiosis in young stock.

Temperature, respiration rate and heart rate: The normal values for temperature, respiration and heart rate are given below:

	Cattle	Sheep	Goats
Body temperature	38.5°C	39.0°C	38.5°C
Respiration rate	25 –40 per minute	12 –20 per minute	15 –25 per minute
Heart rate	40-100 per minute	60-120 per minute	70-135 per minute

Increased temperatures are usually due to infection, but can sometimes be due to fear, exercise or increased ambient temperatures. If in doubt as to the significance of a reading, check others in the group to establish the normal. Sub-normal values may be more significant than raised values, particularly in gastro-intestinal conditions

Colour of mucous membranes: The inner surface of the conjunctiva is a good place to look for this, although the inside of the mouth or the vulva can also be used.

The mucous membranes should normally be pink. Paleness may indicate anaemia; yellow discolouration (jaundice) is due to liver disease; redness may be local inflammation or a sign of systemic disease; blue discolouration (cyanosis) usually indicates circulatory collapse.

Dehydration: If the fluid output, (via diarrhoea, vomiting, urine, sweat and respiration), exceeds the fluid intake, then animals will become dehydrated. Evidence of this can be detected in the elasticity of the skin. If a fold of skin is pinched between the thumb and forefinger, it should return immediately to its former position when released. If it “tents”, then the animal is approximately 5% dehydrated. If dehydration approaches 10%, fluid is lost from the fat pad at the back of the eye and the eye appears to retract into the socket (sunken eye). This is a serious level of dehydration which is life threatening if it remains uncorrected.

Other diagnostic aids: These include laboratory tests on tissue samples, (blood, urine, faeces etc) and the use of ultrasound or X-rays. Examples are the examination of rectal swabs for bacteria, blood tests for the presence of antibodies to disease, skin scrapes for ringworm or parasites, and ultrasound examination for pregnancy.

Ruminant Diseases

1) Notifiable Diseases

Under the Animal Health Act 1981, a number of important diseases are designated as notifiable. The law requires that the existence, or the **suspicion** of existence, of a notifiable disease must immediately be reported to the police or to DEFRA. Various orders under the Act give extensive powers to the authorities to prevent certain diseases entering the UK (ie Foot and Mouth, Bluetongue), to eradicate diseases already present (ie Tuberculosis), or to control the spread of others (ie Salmonellosis, E.coli O157).

Most of the notifiable diseases are potentially or actually of considerable economic significance to the UK livestock industry. Some of them are also zoonoses (BSE, TB). The notifiable diseases of ruminants that are seen in the UK are listed below.

Anthrax:	All ruminants - very rare in UK
Bluetongue:	All ruminants - only seen in UK from 2008 - 10
BSE:	Cattle only
Scrapie:	Sheep and goats - progressive nervous disease
Tuberculosis:	Cattle and goats only

2) Other diseases

Bacterial:	Chlamydia – causes abortion in late gestation in sheep and goats Clostridia – causes fatal septicaemias and toxaeemias in all species E. coli – may cause diarrhoea in the young of all species. Also acute mastitis in cattle Mycobacterium avium paratuberculosis (Johne's disease) – causes ill thrift in all species of ruminants Mycobacterium bovis – causes tuberculosis in cattle and goats (but not sheep) Salmonella species – diarrhoea and septicaemia in all species
Viral:	Caprine arthritis and encephalitis (CAE) in goats and Maedi-Visna (MV) in sheep Bovine virus diarrhoea (BVD) – may cause abortion and enteritis in cattle Border disease (BDV) – may cause abortion in sheep Viral pneumonias (IBR, PI3, RSV) – principally important in young cattle Contagious pustular dermatitis (orf) – a viral skin infection of sheep and goats
Fungal:	Ringworm – causes irritant skin lesions in all species
Parasitic:	Toxoplasmosis – causes abortion at all stages of gestation in sheep and goats Neospora – can cause abortion in cattle Nematodes – (gastro-intestinal worms) – cause diarrhoea in young-stock of all species Trematodes – liver fluke – cause liver damage and diarrhoea in all ruminant species Coccidiosis – protozoan intestinal infection causing diarrhoea in all species Ectoparasites – lice and mange, causing skin irritation in all species

NOTES:

- 1) The caprine arthritis and encephalitis (CAE) virus produces arthritis, encephalitis, pneumonia and mastitis in goats, but a slightly different disease in sheep, where it is known as Maedi-Visna.
- 2) Bovine Virus Diarrhoea (BVD) is common in cattle. It is essentially the same virus as that which causes Border Disease in sheep.
- 3) Sheep are only very rarely infected with Mycobacterium bovis, the cause of tuberculosis in cattle and goats.
- 4) Sheep are very susceptible to infectious agents causing abortion and a number of other zoonotic conditions.
- 5) Young cattle are commonly affected with a number of respiratory viruses causing pneumonia.

Vaccination: There are a number of vaccines available for use in cattle and sheep in the UK, but only 2 are licensed for use in goats. Both of these are against *Clostridial* diseases. The other sheep and cattle vaccines are not licensed for use in goats, and should therefore only be used under the direction of the Named Veterinary Surgeon.

Ruminant Anaesthesia and analgesia

Particular considerations

- 1) **Local anaesthesia:** Local anaesthetics are widely used in cattle and sheep, but goats are particularly sensitive to their effects and they should be used with caution in this species. This is particularly true of kids, where overdose is relatively easy.
- 2) **General anaesthesia:** All of the ruminant species present particular problems with general anaesthesia.
 - 1) Starvation for 18-24 hours in ruminants does not significantly reduce the volume of the rumen contents and is of debatable value. Ruminants will eat their bedding, so to be effective, the animals must be held without bedding for the starvation period. Some authorities suggest that a period of starvation will reduce the production of gas in the rumen (see (4) below), but this does not seem to be an advantage that is worth the distress and metabolic upset caused by starving the animal.
 - 2) The large dorsum of the tongue makes passage of an endo-tracheal tube more difficult than in non-ruminant species. A good laryngoscope is very helpful.
 - 3) All ruminants produce copious quantities of saliva to aid digestion. Normally this saliva is swallowed with the cud, but under anaesthesia the swallow reflex is lost. Unless this saliva is drained away, it will pool in the back of the throat and may then pass into the trachea, and thence the lungs. This can lead to post-operative complications, which might include pneumonia and death. Unfortunately the anti-cholinergic drugs that are used in mono-gastric species to reduce the production of saliva, do not work so well in ruminants. Although they reduce the volume, they cause it become very viscous and therefore more difficult to deal with. These drugs are best avoided in goats. Instead, prevent the inhalation of saliva by passing a cuffed endotracheal tube, and also by lowering the animal's head such that the saliva will drain out of the mouth, and not pool in the pharynx.
 - 4) The rumen will continue to produce gas during anaesthesia, but the unconscious animal is unable to eructate it. Over time, the normal gas-cap in the rumen will enlarge and eventually distend the flanks, causing tympani. For anaesthetic procedures lasting more than 30 minutes, a stomach tube should be passed into the rumen (via the mouth) to allow this gas to be vented.
 - 5) In lateral and dorsal recumbence, the weight of the rumen can restrict both the functioning of the diaphragm and the return circulation of blood from the abdomen to the heart via the major vessels. For this reason, ruminants should never be restrained in these positions for any longer than absolutely necessary for the performance of the surgical procedure.
 - 6) In lateral and dorsal recumbence, the oesophageal-rumen sphincter will lie below the fluid line of the rumenal contents. Under anaesthesia, the sphincter will relax, allowing reflux of ruminal contents into the oesophagus, and thence into the pharynx and mouth. The passage of a stomach tube, as in (4), should help to control this.

Pre-anaesthetic preparation

Before general anaesthesia is undertaken, there are some simple pre-operative procedures that should be carried out:

a) Acclimatisation: If the animal has recently been introduced to the unit, allow an acclimatisation period of at least 1 week, and preferably 2 weeks, before surgery. During this period the metabolic and hormonal changes caused by the stress of moving will return to normal.

b) Health check: Make sure that the animal is in good health. Carry out a clinical examination immediately before anaesthesia, checking cardiovascular and respiratory function.

c) Fasting: Fasting overnight before general anaesthesia is usually advised for ruminants, although this makes little difference to the volume of the contents of the rumen. It may reduce the amount of gas produced.

d) Pre-medication: The use of premedicants prior to anaesthesia is very useful in ruminants.

Sedatives

Will help to reduce anxiety in ruminants prior to the induction of anaesthesia. Sedatives will also reduce the total dose of anaesthetic required and provide a smoother induction of anaesthesia.

The following sedatives are used in the ruminant species

- **Xylazine (Rompun):** Only licensed for use in cattle, where it is a very powerful sedative at a low dose. The use of xylazine is not recommended in sheep or goats, as the safety margin is low and deaths have been reported.

Unfortunately, there are no sedatives licensed for use in sheep and goats, but the following have been found to be safe and effective in these species:

- **Diazepam (valium):** Give 2mg/kg i/m or 1mg/kg i/v.
- **Midazolam (hypnovel):** Give 0.5mg/kg i/v.
- **Acepromazine (ACP):** Give 0.05 – 0.1mg/kg i/m

Anticholinergic drugs

Do not use these in ruminants. Although they reduce the volume of salivary and bronchial secretions, they increase their viscosity, which makes them very difficult to deal with.

General anaesthetic agents

As with many species, **Isoflurane** is the anaesthetic agent of choice in ruminants. The depth of anaesthesia with a volatile agent can be accurately controlled via a calibrated vaporizer, and recovery is rapid. For the reasons given above, ruminants should always be intubated.

However, it is not safe, practical or humane to induce anaesthesia with isoflurane in ruminants larger than 10 kgs, and so induction with a short-term agent given by the intravenous route is usually necessary. The jugular vein is the route of choice, although the cephalic vein may also be used in young animals. Experience shows that the following intravenous agents are safe and effective in ruminants.

- 1) **Propofol (Rapinovet and others)** 4-5mg/kg i/v, is an injectable anaesthetic agent that will give approximately 5 minutes anaesthesia. This is usually sufficient for endotracheal intubation, or for very short procedures.
- 2) **Alfaxalone (Alfaxan)** 2-3mg/kg i/v is the injectable anaesthetic agent of choice for surgical procedures where maintenance under isoflurane is not possible. The dose will be reduced by approximately $\frac{1}{2}$ if the animal is previously sedated, and this will also promote a smoother recovery. A single dose of alfaxalone will give surgical anaesthesia for approximately 20 minutes, but this can be extended by incremental dosing without significantly prolonging the recovery time (approximately 30 minutes).

NOTE: Ketamine (Vetalar and others), when combined with an alpha 2 agonist such as xylazine or medetomidine, does not give good anaesthesia in ruminants and is not recommended. Although it can give light surgical anaesthesia, it has no advantages over propofol or alfaxalone.

Analgesics

There are no licenced analgesics for use in sheep or goats in the UK, although there are some licensed for use in cattle. However, there is evidence that the compounds licensed for use in cattle are safe and work satisfactorily in sheep and goats.

a) Non-steroidal anti-inflammatory drugs (NSAID's)

Some of the newer compounds are effective analgesics for mild to moderate pain in ruminants.

- 1) Flunixin (finadyne solution)
- 2) Meloxicam (metacam)
- 3) Ketoprofen (ketofen)

b) Opioids

Although these are generally speaking more powerful analgesics than the NSAID's, their duration of action can be very short and their effects can vary considerably between the species. They must be used with care as they may also have respiratory depressant effects. For ruminants, Butorphenol (Torbugesic) is the analgesic of choice. Mixed with a sedative, such as diazepam or miazolam, this combination can have a profound sedative/hypnotic effect.

c) Other

The intensity of pain reported by man is increased by emotions such as fear and apprehension. The use of sedative drugs, such as Xylazine (Rompun - Bayer) in cattle, or diazepam (Valium) in sheep or goats, is valuable in reducing apprehension prior to a surgical procedure.

Humane methods of killing

Schedule 1 methods:

Mature forms

- 1) Overdose of anaesthetic
- 2) Destruction of the brain by free bullet (when performed by a veterinary surgeon) *
- 3) Captive bolt, percussion or electrical stunning, followed by destruction of the brain or exsanguinations, before return to consciousness (when performed by a veterinary surgeon or licenced slaughterman) *

Foetal forms

- 1) Overdose of anaesthetic

* Methods (2) and (3) above are not Schedule 1 methods of killing unless carried out by a veterinary surgeon (or a licenced slaughterman in the case of (2)). They may only be used by others under ASPA as non-schedule 1 methods of killing, under PPL and PIL authority.

FURTHER READING

- 1) Handbook of Lab Animal Management and Welfare: Wolfensohn and Lloyd
Oxford University Press ISBN 1-4051-1159-3
- 2) The Laboratory Small Ruminant: M Allen and G Borkowski, CRC Press ISBN 0-8493-2568-4
- 3) Goat Health and Welfare: D Harwood, Crowood Press. ISBN 1 86126 824 6
- 4) Taylor P M (1991): Anaesthesia in sheep and goats. Veterinary Record: In Practice 13 p31-36
- 5) Laboratory Animal Anaesthesia: Elsevier Academic Press ISBN 0-12-260361-3

Appendix 1

BIOLOGICAL DATA

	CATTLE	SHEEP/GOATS
Adult weight of female	600-700 kgs	50 – 80 kgs
Life span	15 – 20 years	12 – 15 years
Blood volume	60 ml / kg	60 ml / kg
Puberty	12-14 months Usually mated at 15 months of age to calve at 2 years	5-6 months First mated either at 7 months or at 19 months (as seasonal breeders)
Gestation	282 days (274 – 291)	145 days (142 – 149)
Litter size	Normally single calf but twins relatively common	Normally single or twin lambs/kids but triplets or quads are relatively common (according to breed)
Birth weight	25 – 50 kgs	3 – 6 kgs
Weaning age	Usually artificially reared from 2 days of age and weaned at 6 weeks.	Sheep - usually 14-18 weeks, but with some systems can be as early as 6 weeks Goats – kids from milking goats are often weaned at 2 days of age and artificially reared, as for calves