Camelids (Old and New World)

Introduction

Camelidae (camelids) originated in North America. They split into Old World (OWC; also known as Camelini) and New World (NWC; also known as Lamini) Camelids. The ancestors of the Old World camels (dromedary, domestic Bactrian camel, and wild Bactrian camel) migrated across the Bering Strait land bridge during the Pleistocene epoch approximately 3 million years ago. They are now found in the eastern hemisphere including Africa, Arabia, and Asia. New World camelids travelled across the Caribbean land bridge at about the same time and are now found in South America. Both OWC and NWC adapted to sparse harsh environments (arid desert and high-altitude mountains, respectively).

The majority of camelids used for scientific research in the UK are New World (e.g. llamas and alpacas), so they will be the primary focus of this course.

New World camelid terminology

Female	Hembras
Male – uncastrated (entire)	Machos
Male - castrated	Gelding
Process of giving birth	Unpacking
Young (<6 months)	Cria
Young (6 to 1 year)	Tuis
Male llama x female alpaca	Huarizo

Note: Old World Camel terminology is similar to the terms used for cattle in the UK (e.g. a female is a 'cow'; male is a 'bull', castrated male is a 'bullock.')

Of the New World camelids, the domestic Llama (Lama glama) are the largest. They were domesticated from the guanaco (Lama guanicoe) approximately 5,000 years ago.

Old World camelid species

Old world camels are able to close their nostrils to prevent sand from entering their respiratory system. They also have long eyelashes for protection from sand. To persevere fluids, they do not sweat as much as other ungulates and when they exhale their nostrils trap water vapor. OWC store fat in their hump(s) which can be used as an energy source during long treks. This breakdown of fat produces water that sustains the animal during times of draught or on long treks across arid regions. When water is present, they can drink 30 gallons of water in 10 minutes.

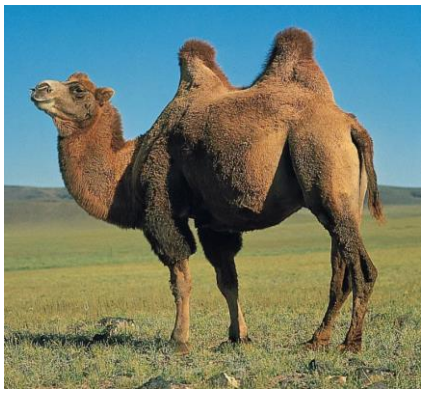
The 3 species of Old World camelids:

<u>Dromedary (Camelus dromedarius)</u> – Approximately 90% of camels, has one hump. Found in North Africa and central Asia.

Although Dromedary camels are considered domesticated, some live in the wild in Australia. These feral Australian camels were left behind by colonialists. The feral dromedary population size was estimated at over a million in 2008 with the ability to double every 8 to 10 years. A control and management plan was put into place in 2013 to maintain a population size of approximately 300,000 individuals. In Australia they are used for meat, milk, and as a disease-free population for live export to Saudi Arabia, UAE, Brunei and Malaysia.

Picture: Dromedary camel

<u>Domestic Bactrian</u> (Camelus bactrianus) – has two humps, is larger than the dromedary camel, but its body is smaller and thinner with shorter fur. The current population is approximately 2 million across Central Asia. Bactrian camels are tolerant to cold, heat, and draught and were used as a pack animal across Asia on the 'silk road.'



Picture: Domestic Bactrian camel

<u>Wild Bactrian (Camelus ferus)</u> Has two humps similar to the Domestic Bactrian. The two species split from one another approximately 1 million years ago. The Wild Bactrian camels are found only in the Gobi desert of China/Mongolia. Unlike other Old World camels, they can survive a wide range of temperatures -20^{0}C in winter to +30^{0}C in summer. Wild Bactrian camels grow thick woolly coats that are shed in spring. There are less than 1,000 in in the wild and they are listed on the IUCN Red list as 'critically endangered.'

Picture: Wild Bactrian camel

New World camelid species

4 species of New World camelids (Lomoids):

Vicuña (Vicugna vicugna; prev. Lama vicugna) – small in stature and timid wild South American camelids. They live in the high alpine areas of the Andes. They produce small amounts of fine fibre that only Inca royalty was allowed to wear. The high value of Vicuña fibre is partly due to only being able to shear the animals every three years.

Picture: Vicuñas

Alpaca (Vicugna pacos; prev. Lama guanicoe pacos) – Using DNA analysis, the domesticated alpaca was identified to be the descendent of the wild Vicuña (approximately 6000 years ago). The two breeds of alpaca are Suri and Huacaya. Alpacas produce high quality fibre and are also a potential source of meat. Alpacas were seen by the Spanish conquistadors as competitors for their sheep grazing so they were slaughtered almost to the point of extinction. There are currently over 35,000 alpacas registered in the UK.

Picture: Huacaya alpaca

<u>Guanaco</u> (Lama guanicoe) – wild camelid of South America, larger than the Vicuña. They are found in the high-mountain regions of the Andes as well as on the lower plateaus, plains and coastlines of Peru, Argentina (Patagonia region), and Chile. Guanaco were described by Charles Darwin as an elegant animal with a long slender neck and fine legs. They produce a thick warm fibre. The fibre is double coated with course guard hairs and soft undercoat (a characteristic maintained in the domesticated llama). The pelts are used as a substitute for red fox pelts as they look very similar. The 2016 population of Guanaco in Argentina was estimated at over 1.9 million. This is considered to be only 3 to 7% of the guanaco population present before the Spanish conquistadors arrived.

Picture: Guanaco

<u>Domestic llama</u> (Lama glama) – Llamas are the largest of the lamoid species and DNA analysis indicates that it is the descendent of the guanaco (approximately 6500 years ago). Thus, llamas originated in the South American Andean Mountain region. The llama is widely used as a meat and pack animal (can carry 25 to 30% of body weight). In its native region, it is also used for tallow for candles and dried dung for fuel. Llama fibre is made-up of course guard hairs of the protective outer coat (about 20%) and the short crimped (wavy) fibre of the insulating undercoat. This makes the fleece less desirable than the fine fibre of the alpaca.

Picture: Domestic Llama

Comparison of Llamas and Alpacas

	Llama	Alpaca
Scientific name	*Lama glama*	*Vicugna pacos*
Adult weight	120–200 kg	60–80 kg
Adult height (measured at withers)	102–127 cm	76–97 cm
Breeds	No distinct breeds	2 breeds: **Huacaya**: lofted fiber coat with variable fiber down legs and face **Suri**: flat-lying corded fiber structure (hanging pencil-sized locks); decreased fiber on head
Ears	Longer banana-shaped ears	Shorter spear-shaped ears
Tail	Higher set tail	Lower set tail
Back	Flat topline	Some humping of back

Table taken from: https://www.msdvetmanual.com/exotic-and-laboratory-animals/llamas-and-alpacas/overview-of-llamas-and-alpacas

Biology

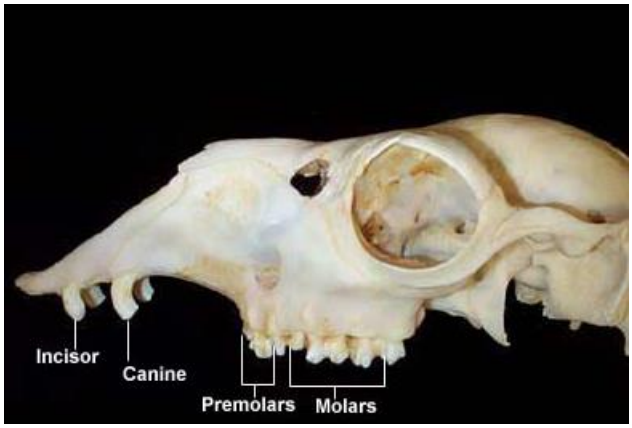
Skin & Hair: Camelids display great variety across species and breeds of wool fibre. They are covered in dense hair called fibre. Unlike sheep's wool, they do not have lanolin. Lanolin is an oil excreted by the sheep's skin and serves as a protectant and waterproofing mechanism.

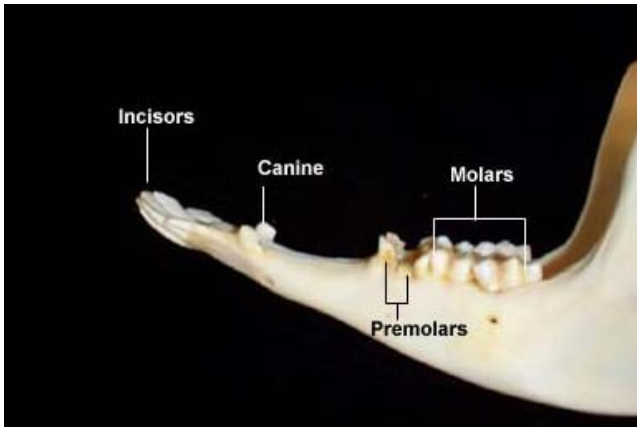
Camelids are prone to skin conditions caused by nutritional issues (e.g. zinc deficiency) and external parasites (e.g. chronic infestation Chorioptic mange).

Camelids do not have horns or antlers that are found in many other ungulates (e.g. sheep, cattle, deer).

Teeth: It is difficult to inspect teeth as their mouth does not open very wide. They have dental pads on the roof of their mouth (like other ruminants).

Camelids have modified incisor and canine teeth known as 'fighting' or 'fang' teeth. There are two on the upper jaw and one on the lower jaw. The fighting teeth erupt through the gumline in males between 2 to 3 years of age and in females at 4 to 5 years. All teeth should have erupted by age six and they continually grow until around 8 years of age.





Pictures above and dental formulae below are from:
https://vivo.colostate.edu/hbooks/pathphys/digestion/pregastric/llamapage.html

Dental Formulae	
Deciduous $\frac{1\ 1\ 2\ (3)}{3\ 1\ 1\ (2)}$ = 9 (11)	**Permanent** $\frac{1\ 1\ 1\ (2)\ 3}{3\ 1\ 1\ (2)\ 3}$ = 14 (16)

Tooth Eruption	
	Permanent
Incisors	2 - 4 years
Canine	2 - 3.5 years
Premolars	3.5 - 5 years
Molars	6 months - 4 years

The cheek teeth (molars) have crescent-shaped ridges on the grinding surfaces, characteristic of ruminant mammals. Upper incisors are present; young have 3 on each side, but adults have only one, which is canine-like. The lower incisors project forward and can act as a spoon/spatula for

eating. The canines, which are present in both upper and lower jaws, are medium-sized and hooked. A wide gap separates incisors and cheek teeth.

Tooth abnormalities in camelids are very common and require regular treatment and management.

Feet: Have two digits on each foot with a nail, not a hoof and the entire bottom surface of the foot is covered by a thick, cornified, but pliable sole (digital foot pads).

The third and fourth metacarpals/metatarsals fuse to form the canon bone (shown in radiograph below at a 60-degree angle from the ground) while the metacarpals/metatarsals furthest from the body separate and splay. Camelids are the only plantigrade (or fully digitigrade) ungulates. Camelids place the full length of their foot on the ground during each stride (e.g. humans and bears) and they walk with the length of their digits (sole of their feet). Most ungulates (unguligrade) walk on their 'tiptoes' often on hooves (e.g. deer, horses).

Radiograph picture from: https://veteriankey.com/musculoskeletal-surgery/

Circulatory system: The circulatory system of llamas and alpacas are adapted to high altitude low oxygen environments. Although most mammals have biconcave, circular, and, anucleated Red Blood Cells (RBCs), camels contain ovoid (elliptical) shape and nucleated red blood cells. Camelid RBCs can expand twice as much of their total volume in the case of rapid hydration yet will not deform under mechanical stress. This ensures the survival of camels in adverse conditions of drought.

Digestive system:

Camelids are strict herbivores and very efficient grazers of rough pasture. They are fore-gut digesters and have a three-compartment (chambered) stomach that evolved similarly to the digestive system of true ruminants (e.g. cow, sheep, goat). However, the three stomachs are not directly comparable to the four stomachs of ruminants, so they are sometimes referred to as 'pseudo-ruminants.' The forestomaches are described as compartments C-1, C-2, and C-3 that similar to a true ruminant's stomach facilitates absorption of fatty acids, water and electrolytes.

The hump present in Old World Camelids is fat which when breakdown releases water. Water is also conserved by concentrating urine and producing very dry faeces. The faeces may be used instantly as a source of fuel due to the extremely low water content. Camels can tolerate up to 25% loss of bodyweight due to loss of water.

Reproductive system: Camelids are seasonal breeders, although camelids living outside of their natural range may breed year-round. In the UK, breeding usually occurs in the summer. Breeding ratios are usually between 5 and 12 females to a male.

Females reach maturity between 12 to 28 months of age, males around 2 years of age. Females are bred when they are at least 24 months old and weigh 40kg (alpaca) or 90kg (llama). Mating is in the 'cush' also spelt 'kush' position (laying down on abdomen with feet folded under the body) and females will 'spit off' the male if not receptive.

Camelids are induced ovulators which means they do not exhibit oestrus behaviour. Ovulation is 'induced' by penile penetration of vagina and cervix. The semen in camelids contains an ovulation induction factor. Ovulation then occurs 24 to 30 hours after mating. A rectal scan of the female to confirm that she is pregnant is often done after 28 days gestation. If the female does not become pregnant, she will resume the normal 13 to 14 day cycle of receptivity to the male.

Gestation is around 342 ± 10 days, with alpacas having a shorter gestation. This is highly variable, and gestation may be up over 12 months (380 days) long. They usually give birth to a single newborn called a 'cria.'

Various Reproductive Parameters of Female Llamas and Alpacas

Parameter	Guideline
Age of puberty	10–12 months
Recommended age of first breeding	At least 2 years and weighing >40 kg (alpaca) or 90 kg (llama)
Gestation period	332–352 days
Size of a mature follicle	>7 mm
Time of pregnancy diagnosis	Female rejects male: 15 days after mating Transrectal ultrasonography: >21 days after mating Rectal palpation: >45 days after mating (llamas) Transcutaneous ultrasonography: 45–60 days after mating
Duration of stage I labor	1–6 hr
Duration of stage II labor	< 30 min
Duration of stage III labor (passage of placenta)	4–6 hr
Time interval after birth to conceive again	14–21 days

Table taken from: https://www.msdvetmanual.com/exotic-and-laboratory-animals/llamas-and-alpacas/overview-of-llamas-and-alpacas

Relevance to Research: Camelid unique physiology makes them the best animal model for many research studies. For example:

- Haematology research due to camelids:
    - Ability to produce an unique antibody that can neutralize 60 strains of HIV
    - Blood cells that are elliptical shape, nucleated, and can expand over 200% when re-hydrated with large amounts of water after a long time without being able to drink water.
- Influenza D Virus (IDV) research; New World (alpaca) translational research for Old World (dromedary camel) IDV infection.
- Reproductive research in mammals (camelids are induced ovulators not spontaneous ovulators like most mammals).

Husbandry

Housing & stocking density: Although there are no HO guidelines for stocking densities or housing for camelids, there are welfare standards listed in the Code of Practice as requirements for all protected animals and there are also welfare standards that have been developed (e.g. UFAW for farmed animals) that list minimum expected requirements.

Camelids are herd animals with a distinct social hierarchy. They need social and visual interaction with other animals. Camelids are normally kept outdoors throughout the year in the UK. They must be provided with shelter from extreme conditions (e.g. wind, rain and sun). Llamas and alpacas may get heatstroke, especially if they are not shorn. The shelter must allow for them to stand, lie down, rest and reasonably move about. Do not overcrowd them, they need space to avoid dominant animals.

If kept indoors, animals should have a 'living area' large enough for them to move freely and exercise independently. Animals should not be singly housed unless entire males. Single housing of entire males is sometimes done to prevent fighting if nonpregnant females are present.

Outdoors – fencing needs to be 5 to 6 feet high
Indoors – allow headroom for them to rear-up on hind legs.

Camelids use communal dung piles. All animals in a group will urinate and defecate in the same pile (usually corners). Animals will not graze in these areas or downstream of the dung piles.

Temperature and Humidity: Heat stress of NWC must be prevented, especially if animals are not shorn. Using similar temperatures and humidity as used for sheep is appropriate (e.g. if kept indoors, the temperature should remain within the limits of 10-24^{0}C). Crias may need to be kept warmer for the first few days of life. As they age, they will tolerate the same conditions as adults. Buildings should be designed to prevent prolonged periods of high humidity, as this may cause excessive dampness in the animal enclosures, predisposing the animals to diseases (e.g. respiratory).

Ventilation: In an indoor environment, a minimum air flow of 10 to 12 air-changes/hour is usually required. If air temperature and humidity are high, the number of air-changes will have to increase accordingly. In addition, the heat generated by the stocking density of the animals and equipment in the room may impact the ventilation required.

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: Ensure animals have sufficient room to all eat at the same time.

Camelids need fodder with high fibre content for normal digestion and metabolism. Long fibre is better than chopped fibre. Rough grazing is better than lush grazing. Grass that is too rich can lead to metabolic in-balances, indigestion, and the development of behavioural disorders.

In the winter, if kept outside, animals should be supplemented with hay. Camelid formulated concentrates (usually contains additional Vitamin D) may be fed to young or pregnant animals but beware of obesity. Legumes are usually not needed and may contribute to obesity. Palpating the amount of tissue over the neck, the lumbar vertebrae, and the ribs can best assess body condition. Body condition is generally scored from 1 (emaciated) to 5 (obese), with 2.5 to 3.0 being ideal.

Mineral supplementation may also be required as the Andes (high mountain) native vegetation would contain high mineral contents. Beware of ionophores found in many cattle feeds, these are highly toxic to camelids; pelleted or mixed grain feed intended for ruminants should not be fed to camelids. Copper toxicity is another concern if using ruminant feeds.

Behavioural problems can develop in animals in too close of contact with humans (e.g. bottle feeding). Assistance in feeding of pre-mature or sick crias should always be done in the presence of dam and be discontinued as soon as the cria is able to exhibit natural feeding behaviours. Bottle feeding rarely impacts the willingness of the cria to feed from the dam.

Water: Clean water must always be available.

Bedding: Soft bedding (e.g. deep dry straw, sand, cattle comfort mats or wood shavings) should be provided. This will aid in preventing pressure sores from cushing.

Environmental enrichment: Camelids with ad-lib access to hay/pasture do not usually develop stereotypes.

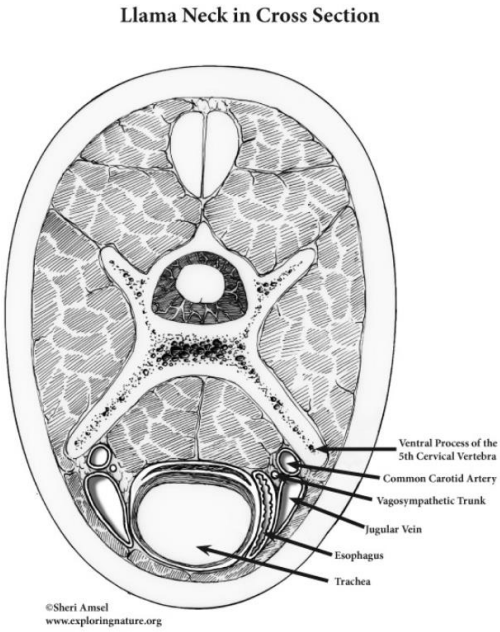
When kept in an indoor facility, youngsters may respond to toys, but adults may tire of them. If indoors, having a salt block may prevent urolithiasis in males. Hanging edible branches or placing hay in nets may add diversity to grazing routine.

Routine tasks:

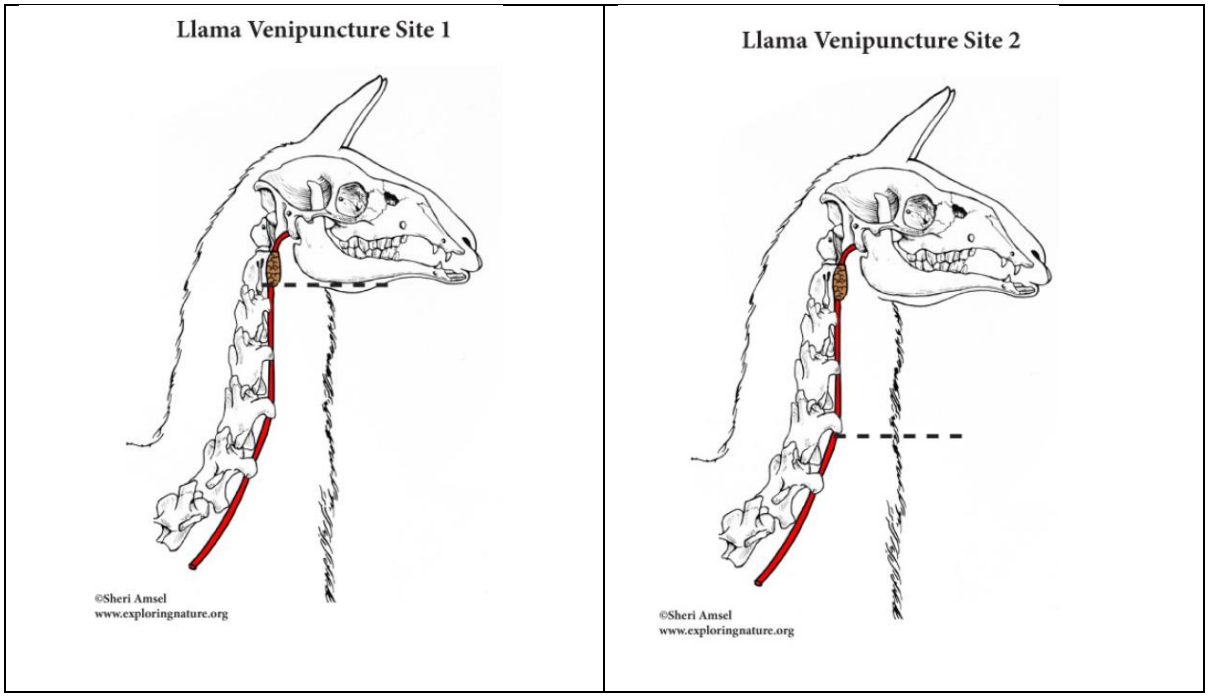
- Due to the inbred genetics of NW Camelids (especially alpacas), crias often do not receive the appropriate immunological protections via colostrum and will need supplemental IgG and/or a blood transfusion to thrive.
- Due to teeth malalignment (overshot or undershot of jaw), monitoring of the teeth should regularly be done to ensure that feed provided is adequately ingested.
- Monitoring of feet to ensure that the nails and soft pads of the feet are properly aligned and in good condition.
- Shearing to prevent heat stress.
- Males should not be castrated until they have reached skeletal heigh maturity (18 to 24 months). Castrating males at an early age may cause bone abnormalities.

Administration of substances: The inoculation sites and sampling techniques for camelids will be demonstrated during the practical session.

Intravenous injection / Blood sampling: The jugular vein of camelids are the preferred sites for intravenous injection and blood sampling. Unlike other species, the jugular vein lies under a thick muscle which protects the artery and vein from the fighting teeth of an attacking animal. This can make learning to take a blood sample in camelids difficult. Due to presence of the oesophagus medial to the left internal jugular vein (see picture below), venipuncture and catheterization of the right jugular is preferred over the left. Inadvertent arterial puncture is a potential complication due to the proximity of the jugular veins to the common carotid arteries. If an artery is punctured instead of a vein, high pressure and bright red blood will fill the syringe or vacutainer. Digital pressure should be applied for few minutes to prevent hematoma formation.



Picture (above): Location of jugular vein in relation to oesophagus, trachea, and 5th cervical vertebra.



Picture (above): Two primary jugular venipuncture sites in relation to the vertebrae.

In order to take a blood sample from the lower site (upper/rostral site '1' may be used, but requires greater restraint so is not the preferred site unless the animal is well behaved or sedated).

In order to take a blood sample from site '2', identify trachea and put thumb between C6 ventral process and trachea. The needle should be at an acute angle (approximately 20 degrees) over the top of the thumb. Using the left-hand thumb on right side of animal is usually easiest for right-handed people.

Personal Safety

a) Handling and restraint

The key to working with camelids is training. Llamas and alpacas have lived in domestication with humans for more than 5,000 years. These animals can be halter trained, taught to walk on a lead, cush (sit in sternal position) on command, tolerate foot trims, and accept basic examination procedures. Camelids should be moved as a group to reduce their fear/stress and potential aggression. Llamas and alpacas will move away from a horizontal barrier, so tapes/ropes can be held between two people in order to calmly and safely move a group into a smaller encloser for examination or procedures. Placing animals in a cush (laying on stomach with feet folded between body and ground) position allows safe and easy examination.

Despite being trainable, sick or in pain Llamas can kick hard enough to break bones, so caution and appropriate handling and restraint is critical for safe working. Camelids typically kick forward (can scratch their nose with their back feet) or to the side so there are no 'safe' places to stand at their side. They can rear up and kick with their front legs in any direction. Restraint can be as basic as one arm around the neck and the other arm holding the tail or flank region on the opposite side. However, sedation may be required in some circumstances.

Camelids will pin their ears back and lift their heads when upset; the degree of pinning and head-lifting indicates just how upset they are. Both llamas and alpacas also make distinctive noises when unhappy and may spit and/or bite. Spitting is usually spewing C1 stomach contents at the person or other camelids. Biting may be dangerous. For example, when a male camel bites, he clamps on and shakes his head, thus potentially causing significant tissue damage.

When a camelid is behaving aggressively or is upset, sedation may be necessary. When manually restraining, maintaining control of the animal's head is important because the neck is quite muscular and can move with great speed. Camelids can be deterred from spitting by placing a cotton bandana or dish towel over the nose and mouth and tucking the ends into the halter. Llamas and alpacas tend not to like the smell of their spit and quickly learn not to spit when muzzled in this manner. Muzzles can also prevent biting.

There are many camelid race and crush systems available to use for larger llamas.

b) Zoonotic diseases

A number of camelid diseases are transmissible to humans, as follows:

- Salmonellosis, especially *Salmonella typhimurium* - severe systemic disease in camelids and

humans.

- *E Coli* including O157 strains - may cause severe diarrhoea in camelids (mostly neonates and recently weaned) and humans.
- Cryptosporidiosis – common enteric infection of humans and animals.
- Tuberculosis (M. bovis and M microti) – both bacteria can cause illness in humans that may be indistinguishable from M. tuberculosis. Symptoms in humans include fever, cough, and weight loss.
- Anthrax - a fatal septicaemia in camelids and humans – very rare in the UK.
- Ringworm - fungal skin condition of camelids, causing itchy skin lesions in humans.
- Sarcoptic Mange – can cause an intensely itchy rash (present in UK)
- Middle East respiratory syndrome (MERS) – found in camels; not currently present in the UK
- Brucellosis – not currently present in the UK

Health and Disease

a) Camelid Health

Biosecurity: Camelids are not included in Schedule 2 of ASPA, so may be purchased from any commercial source including direct from a farm, a dealer, or a market. Such animals will often be of unknown health status, so it is a case of "*caveat emptor*" – let the buyer beware.

Whenever possible, information about the health status of a farm (e.g. TB, BVD, etc.) should be obtained. It is essential that every effort is made to purchase camelids from farms of known health status and to carry out confirmatory health checks prior to their use in a scientific procedure.

Questions to ask:

- Obtain a full history of both the farm and the animal.
- What routine health screenings are carried out?
- Does the farm belong to any voluntary animal health or farm assurance schemes?
- Are any routine vaccinations given?
- Has the animal had any illness or treatment?

Unfortunately, sub-clinical infections can often become clinical if an 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 (or groups) 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.

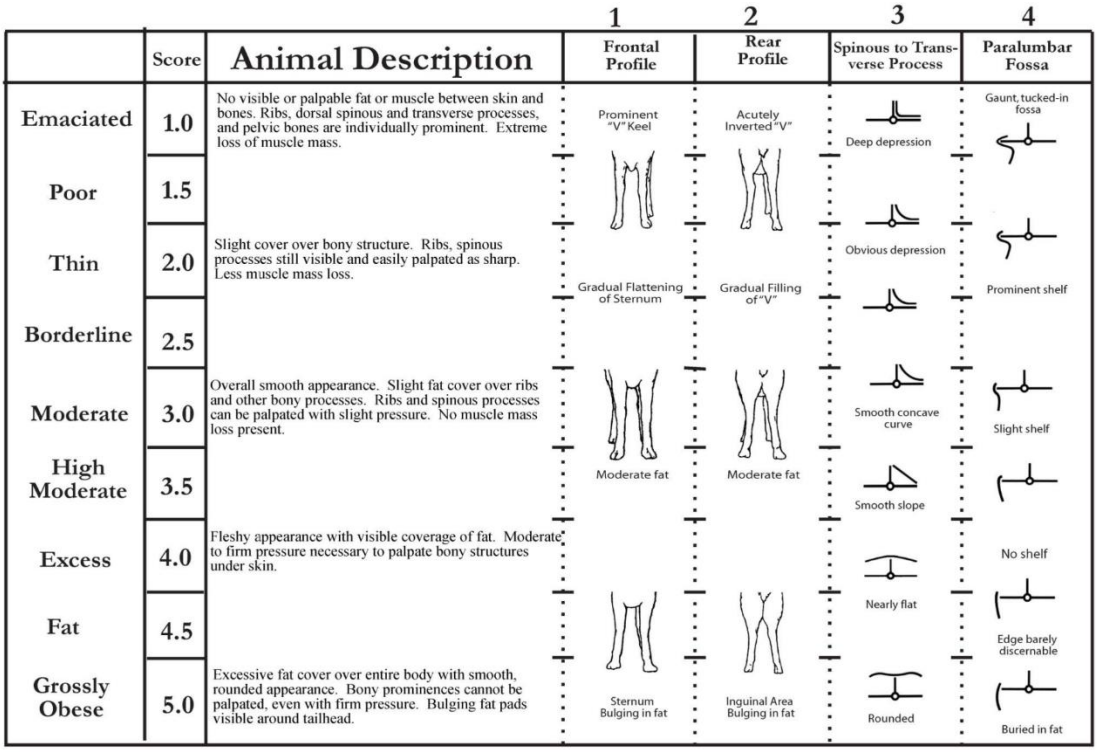
Recognition of wellbeing, pain, suffering and distress

Behaviour: A healthy camelid should be alert, inquisitive and interact with others in the group (normal social behaviour). Inactivity, not eating and/or separation from others in the group is often the first sign that an animal is unwell. It is important to watch their behaviour without disturbing them for a reasonable period and then assess the response when the camelids are disturbed. A sick camelid may hide at the back of a group or lag behind when they are moved.

Other behavioural alternations may include normally docile animals may become aggressive or dominant animals become submissive. Changes in the frequency, posture and productivity at the dung pile. Prolonged recumbency or shifting up and down repeatedly.

Vocalization: Camelids are not very vocal, but they do have a repertoire of sounds that may be altered when they are unwell and/or in pain. Familiarity with the animal's 'normal' sounds are required in order to recognise a change.

Body condition: Assess the condition of the animal and determine if it is well-grown for its age?
There are systems for body condition "scoring", grading between 1 (emaciated) to 5 (obese). A condition score of 2.5 - 3.5 is normally considered desirable. The body condition of camelids cannot be assessed at a distance, feeling of the muscles, fat, and bony processes is required. An emaciated animal can easily be present under a large layer of fleece.



Adapted from Edmonson et al., JDS 1989;72:68 and Russel, A. Body condition scoring sheep, Sheep and Goat Practice 1991.

Appearance of the fleece / skin:

Gait and nervous symptoms: Animals should have a relaxed posture and normal gait, without lameness or ataxia. They should be able to rise from the cush position without difficulty. Camelids kept on firm ground can be particularly prone to lameness. There should be no other nervous signs – body tremors, circling, blindness or head tilt etc.

Respiratory system: When a camelid is at rest, the respiratory movements should be regular and hardly visible. If the respiratory movements 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. If it is difficult to see the rise and fall of the chest, then the flare of the nostrils can be used.

Gastro-intestinal and urinary systems: Prolonged or repeated attempts to defecate or urinate may be a sign of digestive, urinary or reproductive disorders. Animals may exhibit colic-like behaviour of excessive rolling and kicking at their stomachs. There should be no evidence of diarrhoea on their

fleece (faeces should be well pelleted with a low water content). Excessive water or blood in the faeces are signs of illness.

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

Temperature	37.5 - 38.9^{o}C
Respiratory rate	10 - 40 /minute
Heart rate	60 - 90 /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 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, whilst blue discolouration (cyanosis) usually indicates circulatory collapse.

Other diagnostic aids: These include laboratory tests on tissue samples (blood, urine, faeces etc), and the use of ultrasound or X-rays. Examples of tissue sampling 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.

Some laboratory tests will be undertaken to establish freedom from disease in order to protect the health of the other animals in the unit, or the humans who come into contact with them. Other tests may be specifically to establish the health status of an animal prior to use on a procedure.

b) Notifiable Camelid Diseases

Under the Animal Health Act 1981 and subsequent amendments, several important diseases are designated as 'notifiable.' This means the law requires that the existence, or the **suspicion** of existence, of one of these diseases must immediately be reported to DEFRA/DAERA. Various orders under the Act give extensive powers to the authorities to prevent certain diseases entering the UK (e.g. Foot and Mouth); to eradicate diseases already present (e.g. Anthrax). Other orders are designed to control the spread of disease (e.g. *Salmonellosis*).

Most notifiable diseases are potentially or actually of considerable economic significance to the UK livestock industry**.** Some notifiable diseases found in camelids are listed below, with those that are zoonoses marked in **bold:**

- **Anthrax**
- **TB (common in UK)**
- **Rabies**
- Bluetongue virus (BTV)
- Surra (Trypanosoma evansi)
- Glanders (Burkholderia mallei)

- **Q fever**
- Infectious bovine rhinotracheitis (IBRV)
- Foot and mouth disease (FMDV)

c) Other Camelid Diseases

Diarrhoea due to *E. coli*, *Clostridium perfringens*, Rotavirus.

Bacterial	Clostridial – tetanus and entertoxaemias
	Bovine Tuberculosis – M.bovis
	Johnes disease (M. avium paratuberculosis)
	Caseous lymphadenitis
	Enzootic Abortion of Ewes (EAE)
Viral	Bovine Viral Diarrhoea (BVDV)
	Border Disease (BDV)
Fungal	Ringworm

Vaccination: Although no vaccines are licensed for use in camelids in the UK, it is essential that camelids are vaccinated for clostridial disease (e.g. Tetanus). Vaccines licensed for sheep are usually used.

Anaesthesia and Analgesia

a) Camelid-specific considerations

Local anaesthesia: Can provide analgesia with minimal side effects. These formulations may be injected into tissues to provide local infiltration of an area (e.g. around a wound or local/regional/epidural blocks). Procaine (e.g. Pronestesic) and other products are licensed for use in farm animals in the UK (lignocaine is banned from use in farm animals in the UK). Dilute to 2% solution to avoid toxicity issues.

General Anaesthesia issues: Are similar to issues found in other ungulates and include:

- Bloat
- regurgitation and aspiration pneumonia. Like other ruminants this is a risk due to the large stomach and large amount of saliva produced. Endotracheal tube should be placed to protect the airway.
- Impaired respiration and venous return due to the weight of the abdominal viscera on diaphragm and vena cava.

b) Pre-anaesthetic preparation

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

Acclimatisation: If the camelid has been recently 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.

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

Fasting: This may be advisable to prevent regurgitation of food during induction, up to 12 hours should be sufficient. Water does not need to be withheld. Crias (<4 months) should not be fasted due to potential for hypoglycaemia.

Pre-medication: The use of certain drugs prior to anaesthesia may be useful and assist with a quick post-anaesthetic recovery.

c) Drugs used for Sedation/Anaesthesia/Analgesia of Camelids

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

- **Butorphenol** (Torbugesic): 0.05-0.2mg/kg IV/IM
- **Xylazine**: 0.1 – 0.6 mg/kg IV/IM. Reverse with 0.125mg/kg atipamezole
- **Diazepam** (Valium) or Midazolam: 0.2-1.0 mg/kg IV
- **Acepromazine** (ACP): Give 0.03 – 0.15 IV/IM

Anticholinergic drugs: This may be used to reduce the volume of salivary and bronchial secretions, which might block airways, and block the vaso-vagal reflex that causes slowing of the heart during surgical procedures.

- **Atropine**: 0.02 to 0.04 mg/kg IV/IM
- **Glycopyrrolate:** Give 0.005 to 0.01 mg/kg IM

Anaesthetics:

Volatile Gas Anaesthetic: As with many species, **Isoflurane gas** is the most commonly used anaesthetic agent in camlids. More recent volatile anaesthetic agents (Sevoflurane, Desflurane) are alternatives. The depth of gas anaesthesia can be accurately controlled via a calibrated vaporiser, and recovery is rapid. To protect the lungs from fluid aspiration, the camelid should always be intubated. An endotracheal tube must be placed (not a nasogastric tube). Camelids must breathe through their nose, not their mouth, so placing a tube through the nose may cause hypoxia.

Injectable Anaesthetics: These can be used for short procedures, or as a pre-induction for intubation and gas anaesthetic. It is not practical, or necessary, to induce anaesthesia in camelids by inhalation of Isoflurane via a mask. Pre-sedation (as discussed above) is recommended to reduce the animal's movements. Some injectable agents (e.g. Propofol) may cause tissue necrosis if injected outside of the vein. Use of pre-sedation prior to administering a general anaesthetic will also promote a smoother recovery.

These short-duration injectable agents are usually given via the intravenous route. The following are the agents of choice:

- **Propofol (Rapinovet and others):** (pre-sedation required, slow IV titration 'to effect') or 2.0 – 4 mg/kg IV. Propofol is a short-acting anaesthetic giving 5-10 minutes anaesthesia, with very rapid recovery. It must be given intravenously. It is most useful as an induction agent, where it may give long enough anaesthesia to allow endotracheal intubation.

- **Alphaxalone (Alfaxan):** (pre-sedation required, slow IV titration 'to effect') 2.1 mg/kg IV. Alphaxalone is rapidly metabolised and excreted via the liver, to give a quick recovery with few side effects. It should be given intravenously and will give approximately 20 minutes of surgical anaesthesia. This can be extended by incremental dosing without significantly

increasing the recovery time. Alphaxalone can prove expensive for heavier animals, although the use of a pre-medicant sedative will reduce the total dose required.

- **Xylazine or Butorphanol + Ketamine** (given 10 to 15 minutes apart): 0.25 mg/kg xylazine IV followed by ketamine 2.5mg/kg IV or 5 mg/kg IM. Will give approximately 30 minutes of anaesthesia.

- **Tiletamine-zolazepam (Zoletil).** 2mg/kg IM (with pre-medication 30 minutes prior). If pre-medication is not used, 2 - 3mg/kg tiletamine (zoletil) may be combined in a syringe with 0.2 - 0.45mg/kg xylazine (rompun) IM for procedures of 30 to 50 minutes. Unlike, ketamine, Zoletil does not provide any analgesia. It may be used as a practical and effective sedation or if only light surgical anaesthesia is required or for endotracheal intubation.

Analgesics:

There are a number of analgesics that can be used to mitigate pain in camelids:

Non-steroidal anti-inflammatory drugs (NSAID's)**:** Some of the newer compounds are effective analgesics for mild to moderate pain in camelids.

- Ketoprofen (Ketofen)
- Flunixin (Finadyne solution)
- Meloxicam (Metacam)
- Carprofen (Rimadyl)

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 camelids, **Butorphenol (Torbugesic)** is the analgesic of choice for moderate to severe pain.

d) Schedule 1. Standard Methods of Humane Killing

Animals used under ASPA should be killed by a recognised Schedule 1 method, unless another alternative method has been authorised in the Project Licence (PPL). **Animals must first be killed, then death completed or confirmed** prior to post-mortem tissue collection or disposal. Schedule 1 methods suitable for ungulates (hooved animals) are:

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**)

A. Methods for animals other than fetal, larval and embryonic forms	Animals for which appropriate
1. Overdose of an anaesthetic using a route and an anaesthetic agent appropriate for the size and species of animal	All animals.
2. Exposure to carbon dioxide gas in a rising concentration	Birds and Rodents up to 1.5 kg (but not neonatal rodents).
3. Dislocation of the neck (with the prior use of a sedative or anaesthetic in the case of rodents and rabbits over 150 g and birds over 250 g)	Rodents up to 500 g; Rabbits up to 1 kg; Birds up to 1 kg.
4. Concussion of the brain by striking the cranium	Rodents and Rabbits up to 1 kg; Birds up to 250 g; Amphibians and reptiles (with destruction of the brain before the return of consciousness) up to 1 kg; Fishes (with destruction of the brain before the return of consciousness).
5. One of the recognised methods of slaughter set out below which is appropriate to the animal and is performed by a registered veterinary surgeon, or, in the case of the methods described in paragraph (ii) below, performed by the holder of a current licence granted under the Welfare of Animals (Slaughter or Killing) Regulations 1995 **(a)** i) Destruction of the brain by free bullet using appropriate rifles, guns and ammunition, or ii) captive bolt or electrical stunning followed by destruction of the brain or exsanguination before return of consciousness.	Ungulates.

Foetal forms

1) Overdose of anaesthetic

B. Methods for fetal, larval and embryonic forms	Animals for which appropriate
1. Overdose of an anaesthetic using a route and anaesthetic agent appropriate for the size, stage of development and species of animal	All animals.
2. Refrigeration, or disruption of membranes, or maceration in apparatus approved under appropriate slaughter legislation, or exposure to carbon dioxide in near 100% concentration until they are dead	Birds; Reptiles.
3. Cooling of fetuses followed by immersion in cold tissue fixative	Mice, Rats and Rabbits.
4. Decapitation	Mammals and Birds up to 50 g.

FURTHER READING

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ONLINE RESOURCES

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