Reproduction in South American Camelids

Introduction

The South American camelids (SAC or New World camelids) include the llama (*Lama glama*), alpaca (*Lama pacos*), guanaco (*Lama guanicoe*) and vicuña (*Vicugna*[or*Lama*] *vicugna*). Of these four species, only llamas and alpacas have been extensively domesticated. Interbreeding can apparently occur between any of the four species, producing fertile offspring.

Llamas and alpacas are raised for wool production, beasts of burden, pets, and/or show animals. In South America, these animals are also used for meat, and alpacas have been used for hide and pelt production. However, in North America, individual animals can be valuable ($1000 to over $20,000 per animal), so there is considerable pressure to breed them. Reproduction is very similar in llamas and alpacas. Unless otherwise stated, the information presented on cyclicity, puberty, etc. reflects the situation in llamas and alpacas raised under common husbandry practices in Canada and the USA.

Nomenclature

A group of SAC is called a herd or flock. Male SAC are referred to as males or studs and castrated males are geldings. Females are referred to as females or dams. Young SAC from birth to weaning are called babies or crias and from weaning to adulthood are called juveniles. Parturition is called birthing.

General information

The life span of llamas averages 20 years and they can be sexually active from puberty to the end of their lives. An adult male will weigh 135-240 kg (300-530 lb), adult females will weigh 90-180 kg (200-400 lb), and newborns 8-18 kg (17-40 lb). Alpacas are smaller, with adult males weighing 60-80 kg (130-175 lb), adult females weighing 50-60 kg (110-130 lb), and newborns 5.5-9 kg (12-20 lb). The haircoat may make the animal look heavier than it is, so inexperienced veterinarians should obtain weights before calculating dosages of pharmaceuticals.

Obesity is a common problem and may adversely affect fertility in breeding SAC (fat in the scrotum, unable to breed, etc.). South American camelids tend to put on fat around the perineum and in the ventral abdominal subcutaneous region and not on the back. Owners may therefore think their animals are too thin and overfeed them. A common method to assess body condition is to palpate the ribs just caudal to the elbow, the transverse processes of the lumbar vertebrae, and areas around the shoulders.
Puberty

Males can reach sexual maturity at 10-12 months but the penis is often not free from the preputial epithelium until 2-3 years of age. Female llamas usually reach puberty at 10-12 months of age but this can be as late as 2-3 years of age, as age at puberty is closely correlated with body weight and thus, nutrition. Females should not be bred until they are at least 15-18 months old and at least 2/3 of their anticipated mature body weight.

Male reproductive anatomy

The penis and prepuce are directed caudally in their relaxed state. During sexual excitement, a strong protractor prepuce muscle pulls them cranially. The penis is fibroelastic, has a prescrotal sigmoid flexure, and ends in a short cartilaginous process which assists in dilation of the cervix during intromission. Semen is thought to be deposited into the uterus.

The testes are located in a non-pendulous scrotum ventral to the anus. Testicles of adult male llamas usually measure 5.0-7.0 cm long and 2.5-4.0 cm wide. Corresponding measurements for alpaca testicles are 3.5-5.0 cm long and 2.0-3.5 cm wide. Accessory sex glands include only a (transrectally palpable) prostate and a pair of bulbourethral glands.

Breeding soundness evaluation in males

The general principles of breeding soundness evaluation that will be discussed in other species also apply to SAC. Suggested minimum testicular size for mature llamas is > 5.5 cm long x > 3.0 cm wide, with a scrotal width of > 6.0 cm. Corresponding measurements for alpacas are > 4.0 cm long x > 2.5 cm wide, with a scrotal width of > 5.0 cm.

Because of the prolonged mating time and the fact that the male dribbles small amounts of semen during an average 22 minute copulation, collection of a complete ejaculate is difficult. Semen has been collected with variable results using an artificial vagina (which works best when it is mounted inside a "surrogate female" that uses a real female or dummy female as a mount animal\textsuperscript{[1,2,3,7]}, electroejaculation (requires anesthesia and a ram probe is used), an intravaginal condom or sponge, or vaginal aspiration (which may not yield much semen unless the pipette can be passed through the cervix and into the uterus).

There is considerable unexplained discrepancy in the literature on sperm cell concentration and semen quality. Semen quality is apparently better in the winter
months than in the summer. The progressive motility of the spermatozoa is relatively poor; however, the viscous quality of the semen probably inhibits progressive motility. If any (elliptically-shaped) red blood cells contaminate the semen sample, they can resemble loose sperm heads.
Female reproductive anatomy

The anatomy of the external genitalia is unremarkable and the vagina is 11-25 cm long. The cervix has 2-4 rings (bovine-like) that spiral in a clockwise direction. The uterine body is short (3.0-5.5 cm) and the uterus is Y-shaped, but with no intercornual ligaments. The left horn is larger than the right if there have been one or more pregnancies (98% of pregnancies occur in the left horn despite both ovaries being equally active). The uterine horns curl ventrally (bovine-like), especially under progesterone dominance (luteal phase). As in cattle, the uterus has increased tone when under estrogen dominance (follicular phase). A papilla at the uterotubal junction prevents retrograde flow up the uterine tubes (oviducts). The ovaries are bovine-like and measure 1.3-2.5 cm long × 0.5-1.5 cm in width and 1.0-2.5 cm in depth. Alpaca ovaries usually measure in the lower end of the above ranges.

Estrus, ovulation, and the maintenance and termination of pregnancy

South American camelids are non-seasonal breeders unless their nutrition is severely restricted. However, in their natural habitat, the breeding season is confined to January to April. Follicles develop in waves with 11-23 and 8-17 days between waves in the llama and alpaca, respectively. Follicular development alternates between ovaries about 80% of the time. One oocyte is usually ovulated in response to copulation; SAC are induced ovulators. (Spontaneous ovulations occur with an incidence of 3.5-15% and double ovulations occur up to 10-15% of the time but twin pregnancies are rare.) The dominant follicle will grow up to 7-16 mm in diameter. In llamas, a mature follicle can remain on the ovary for up to 10-12 days, after which it becomes atretic. In one study, 18% of nonovulatory follicles in female llamas not exposed to males became oversized (> 25 mm in diameter) and hemorrhagic. These hemorrhagic follicles grew up to 35 mm in diameter, persisted for 2-4 weeks, resolved spontaneously, and did not disrupt ovarian function or interfere with fertility.

Follicles can ovulate at any size from a minimum of 6-9 mm in diameter, if mating occurs. It is believed by some that two to three matings in a period of 2-3 days may be required to trigger ovulation. However, in general, 70-90% of females will ovulate 24-48 hours after copulation and females release luteinizing hormone (LH) only after the first breeding and therefore the benefit of multiple matings is questionable. Alpacas usually ovulate sooner after copulation than do llamas. The life span of a corpus luteum (CL; 10-16 mm in diameter when mature) is 9-13 days in the nonpregnant female and sexual receptivity returns 12-30 days after a non-fertile mating. The corpus luteum is required to maintain pregnancy throughout the gestational period. Prostaglandin F\textsubscript{2alpha} is responsible for luteolysis.
Ovulation can apparently be induced with 50 µg gonadotropin-releasing hormone (GnRH), IM, q8h over a 24 hour period or a single IM injection of 800 µg GnRH, but 500-1600 IU human chorionic gonadotropin (hCG) IM or IV has been reported to be more effective. There are indications in the literature that 100 µg GnRH IM in a single dose might also be effective to induce ovulation.

Lutalyse (a native prostaglandin) is luteolytic at 10 mg SC, repeated in 24 hours; however, hypertension, colicky reactions and deaths have been reported following the use of this drug in llamas. Cloprostenol (a prostaglandin analogue) has been used at a dosage of 150 µg IM to induce luteolysis. Abortion has been induced in llamas up to 7 months of gestation using 2 doses of 250 µg of cloprostenol IM 24 hours apart. Fetal expulsion occurred in approximately 90% of treated animals by 72-96 hours after treatment and there were no adverse reactions or negative effects on fertility.¹⁴

The administration of luteolytic doses of prostaglandins to alpacas within 10 days of their estimated due dates has been reported to induce parturition within 24 hours.¹³ The corticosteroid, dexamethasone, at ≥ 0.5 mg caused fetal death in treated animals.

Breeding behaviour and management

Males determine sexual receptivity by pursuing the females and attempting to mount. The nonreceptive female will run away from the male and spit or kick at him. The receptive female will assume sternal recumbency (a “cush”) and allow the male to mount, usually after a brief period of pursuit. Mating will continue in the recumbent position for 3 to 65 minutes (average, 18-25 minutes). The male makes a guttural humming sound throughout copulation while the female remains submissive and quiet. Other receptive females may lie down close to a copulating pair. Some males may dislike certain females and refuse to mate with them and vice versa. Periodically, males will show reduced libido when running with a group of females and replacement every 1-2 weeks with males that have been isolated from females usually solves the problem. Mature males apparently can run with around 30 females (or approximately 1 male to 15 females on the farm if males are rotated every 1-2 weeks), although the practice of hand mating is a better management technique.

Hand mating involves observing individual pairs by themselves in a pen and works best if the female is brought to the male’s paddock. Hand-mated pairs can be left together for a few days if the female has difficulty conceiving or is not clearly receptive. If breeding does not occur, the pair should be separated for at least 7 days before the next attempt. Breeders often check to make certain that intromission is really occurring during the mating.
The use of multiple males in a breeding situation or contact with other males across fences can reduce breeding activity because of aggression between males.

Infertility

Causes of infertility are similar to those in other species and are discussed in detail in some of the references. The principles of investigation are the same as will be discussed in future courses on other species. It is always important to consider both male and female aspects in any infertility investigation.

Vaginal strictures and adhesions are relatively common defects that are apparently acquired. Follicular "cysts" and the presence of numerous small non-developing follicles are probably most often temporary. Failure of ovulation after breeding is a common problem.

A very high embryonic mortality rate (approximately 33%, with up to 50% losses being reported in some areas, e.g., in alpacas in Peru) in female SAC has been reported but the cause is unknown. Another cause of infertility is damage to the penis by entanglement in the perineal fibre of the female. Shaving the perineal area of the females prevents this problem. Heat stress can reduce fertility, and in unshorn males can result in scrotal edema, hydrocele, preputial edema, increased sperm cell abnormalities and decreased libido.

Pregnancy diagnosis

1. Refusal to mate 15 or more days after breeding with rechecking at 30, 60, and 90 days of pregnancy indicates that the female is pregnant. However, male aggressiveness and some physiological abnormalities can result in the occasional pregnant female accepting the male, leading to a false-negative diagnosis. Males with low libido or nonpregnant females that refuse the male will also decrease the accuracy of this test.

2. Elevated serum (or milk) progesterone levels (>2 ng/ml) at the times stated in #1 would also indicate pregnancy and low levels (<1ng/ml) indicate nonpregnancy. However, persistent CL's (e.g., remaining after embryonic death has occurred) or CL's from spontaneous ovulations have been reported in nonpregnant, nonreceptive females and would elevate serum progesterone levels, leading to a false positive diagnosis.

3. Careful transrectal palpation of the uterus can detect the soft fluid enlargement of the uterus after 30-35 days of gestation but this method is most accurate after 45
days. After 90 days of gestation, the cranial border of the uterus moves out of reach but the fetus can usually be palpated from 90 to 150 days. After 5-6 months, the uterus and its contents might be difficult to palpate because its weight pulls it deeper into the abdominal cavity. However, the fetus usually comes back into reach after 210-240 days of gestation. Pregnancy diagnosis by transabdominal ballottement is difficult.

Good restraint, the copious use of lubricant, and small hand size are recommended for transrectal examination, especially in alpacas (transrectal palpation may not be possible on small alpacas). Some recommend using a combination of 10 parts lubricant to 1 part 2% lidocaine for this procedure.

4. Transrectal real-time B-mode ultrasonography will detect the fluids of the fetoplacental unit 15 days after the initial mating. The embryo can be seen as early as 20 days and the heartbeat can be detected 24-28 days after the initial mating. In smaller animals, it might not be possible to insert a hand into the rectum along with the ultrasound transducer. In such cases, the cord of the probe can be stiffened with a guide and inserted without a hand.

Transabdominal B-mode ultrasonography becomes useful for pregnancy diagnosis after 45-70 days of pregnancy and a high accuracy has been reported up to approximately 90 days of gestation. For detecting pregnancies up to 90 days of gestation, it is recommended that the transducer be placed on the left side of the abdomen, just cranial to the mammary gland. For later stages of pregnancy, examination on the right side might be more effective. However, if a fetus cannot be detected on one side of the abdomen, it is routinely searched for on the opposite side.

Abortion

Causes of abortion have been poorly defined and there may be infectious causes that affect other species that have not yet been confirmed in SAC. Thermal stress, chronic stress, leptospirosis, chlamydiosis, toxoplasmosis, *E. coli*, and salmonellosis have all been implicated as causes of abortion in SAC. Less common causes include twinning, nitrate poisoning, and pine needle toxicosis.

**Care of the dam in the last trimester**

This includes the evaluation of body condition and removal of excessive wool, especially in the perineal area. Deworming depends upon age, previous deworming program,
season, stocking density, degree of confinement, and pasture rotation. Products used include fenbendazole (Panacur or Safeguard) @ 5-10 mg/kg PO X 3 days or ivermectin (Ivomec) @ 0.2 mg/kg PO, once.

If there are no previous vaccinations, the dams should be vaccinated against *Clostridium perfringens* C and D (enterotoxemia) and *Clostridium tetani* (tetanus) 60 days before parturition and again at 30 days prepartum. If they have been previously vaccinated against these diseases, a booster shot at 30 days prepartum is adequate. In selenium-deficient areas, the dam should be supplemented with a vitamin E-selenium injection within 4 weeks of parturition.

**Parturition and dystocia**

The gestation length is 330-365 days (around 11.5 months). There is minimal abdominal enlargement. Placentation is diffuse epitheliochorial and the amnion is adhered to the chorioallantois. Parturition nearly always occurs during daylight hours, and most often between 7:00 a.m. and mid (to late) afternoon. The only physical signs of impending parturition may be waxing of the teats and a slight relaxation of the vulva. Udder development and enlargement of the teats are usually not apparent until the last week or day of gestation, or even after parturition.

In stage 1 of parturition there is restlessness, increased humming, increased frequency of urination and straining to defecate, decreased appetite, and segregation from the herd. This stage often lasts 1.5-3 hours and if it lasts longer than 6 hours, it is considered prolonged.

Stage 2 should last for 10-90 minutes and although the dam may lie down and get up frequently, they usually deliver while standing. Both chorion and amnion may rupture together when the fetus is presented at the birth canal and the amount of fluid released is reduced relative to other monotocous domestic species. There is a slippery fetal epidermal membrane that is attached at the mucocutaneous junctions, hoof coronet, and umbilicus of the fetus that facilitates birth. This membrane dries and rubs off as the fetus struggles after delivery. The normal presentation is cranial, in dorso-sacral position, with the forelegs extended above or below the head. Lack of perineal bulging during early second stage labour may indicate that the fetus is not presented normally into the birth canal. Either the feet or nose can be presented first, but within 30 minutes of the appearance of one or the other, the nose and both feet should be visible. The dam may cease straining for awhile when the fetal shoulders pass through the pelvic canal. Assistance may be required if stage 2 lasts longer than 90 minutes to 2 hours.
Dystocia (difficult birth) is uncommon (2-5%) but the most common causes are fetuses that are too large for the maternal pelvis (especially in primiparous dams) and abnormalities in presentation, position and especially, posture (in pluriparous dams). Torsion of the uterus has also been reported and seems to be common in certain herds. Obstetrical techniques are similar to those that will be described for other large animal species. The legs and neck of the babies are very long and slender. Term fetuses may not respond to the usual viability tests based on fetal movements in response to stimuli that are used to determine if calves, foals, etc. are alive at the time of parturition.

Stage 3 (expulsion of the placenta) occurs between 45 minutes and 3 hours postpartum and the placenta is considered retained if not expelled by 6-8 hours. Retained placenta is uncommon; therapy includes oxytocin (5-20 U IM every 20-30 minutes for 6 treatments or to effect), warm saline lavage of the uterus, and systemic antibiotics (as indicated). However, less than 1% of females will still retain their placentas by 24 hours postpartum and these are mainly the ones that require medical attention, although oxytocin therapy can be initiated earlier.
Postpartum reproductive physiology

The uterus is usually involuted to its normal size by 21 days postpartum. A small amount of lochia may be discharged for the first 5-7 days. Females will accept the male as early as the day of birthing but conception at this stage is rare. Follicular activity resumes as early as 4-6 days after parturition and ovulation can occur as early as 2 weeks postpartum if the female is mated. Conception rates have been reported to be higher when the females were rebred at 2-4 weeks postpartum than when rebred at 2-3 months. Breeding before 14 days postpartum is accompanied by reduced fertility and increased embryonic death.

Care of the cria

The dam will hum and nuzzle the cria but will not lick it. Other herd members will occasionally gather around and hum at the new cria. The navel should be dipped in iodine (suggested 3 treatments in the first 24 hours of life) and a quick physical examination performed. The normal newborn heart rate is 60-100 beats/minute, respiratory rate is 10-30/minute, and body temperature is 37.7-39.2°C.

The cria usually stands within 15-60 minutes and nurses within 60-90 minutes of birth but should nurse by 3-4 hours or intervention may be needed. Crias will nurse every 1-2 hours, with most episodes lasting 1-3 minutes. Colostrum intake during the first 24 hours after birth should be 10% of bodyweight. If colostrum is administered by stomach tube, it should be given in 4-8 oz aliquots every 2 hours. Dysgalactia is a common postpartum problem in SAC. If llama/alpaca colostrum is unavailable, cow, sheep or goat colostrum (up to 20% of body weight) have been used successfully. The usual remedies for failure of passive transfer apply and details on medical care of the neonate are available in the references. Cow, sheep and goat milk have all been used successfully to raise crias. If powdered milk replacers are used, they should be non-medicated or there will be a risk of fungal overgrowth in the oral cavity (which usually resolves after switching to non-medicated feeds).

In selenium deficient areas, 0.5 or 1.0 ml Bo-Se can be administered at birth to alpaca and llama crias, respectively. The meconium should be passed within 24 hours of birth.

Partial or complete, unilateral or bilateral choanal atresia is a relatively common heritable defect that results in the failure of the caudal nares to open during development. There is difficulty breathing and the cria chokes or gags when it nurses. Unless the condition is treated surgically, the cria will often develop aspiration pneumonia and die.
Llama crias should gain 0.5 to 1.0 lb/day and alpacas 0.25 to 0.5 lb/day for the first 2-3 months. They should eat solid food by 2-3 weeks of age, and ruminate by 4-6 weeks. They are usually weaned at 6 months of age.
Suggested references

   a) Reproductive biology of the nonpregnant and early pregnant llama. 1989, pp 166-175.
   b) Infertility in llamas. 1989, pp 234-238.
   e) Prepartum care of the pregnant llama and neonatal care of the cria. 1992, pp 198-201.
   g) An overview of reproduction in the female llama. 1994, pp 235-239.
   h) Perinatal care of the pregnant lamoid and care of the neonate. 1994, pp 240-245.
   i) Method of seminal collection, seminal characteristics and pattern of ejaculation in the llama. 1995, pp 246-249.
   k) Reproductive surgery, prepartum care and management of dystocia, breeding soundness examination of the male, semen preservation and artificial insemination, testicular ultrasonography and biopsy, fertilization, embryo and fetal development, embryo transfer, infertility and the diagnosis of infertility, and evaluation of the cervix. 2001, pp 357-417.
m) Infertility in the male and female, including breeding soundness evaluation, and reproductive surgery. 2003, pp 304-333.


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