Breeding Management of Llamas and Alpacas (V559)

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INTRODUCTION

South American camelids possess some unique reproductive characteristics generally unfamiliar to veterinarians practicing outside of the indigenous zone of the Andes. Camelids are the only large domestic species that are induced ovulators. The term **estrous cycle** must be qualified when used in reference to induced ovulators since a regular cyclic pattern of behavior does not occur as it does in spontaneous ovulators. The terms **receptive** vs **nonreceptive**, and **follicular phase** vs **luteal phase** are more appropriate for communicating "cyclic" changes in camelids. Sexual behavior and copulation time is strikingly different from any other domestic species, gestation is unusually long, and uterine anatomy, placentation, and birthing all have distinctly different characteristics in camelids than any other species. Although the reproductive characteristics of llamas and alpacas appear to be virtually identical, extremely little work has been done directly comparing the two species. As veterinarians, we have been frustrated at the lack of information about the normal reproductive function of camelids. Our inability to distinguish normal from abnormal has made it difficult to diagnose or prognose clinical conditions, or make any meaningful recommendations regarding breeding management. The primary objective of this presentation is to provide the practitioner with a basic understanding of reproductive characteristics of llamas and alpacas, and the implications of endogenous patterns on clinical diagnosis, treatment and reproductive management.

SEXUAL RECEPTIVITY AND MATING BEHAVIOR

In the absence of copulatory stimulation, female llamas and alpacas display virtually constant sexual receptivity. The receptive female will assume the prone position (ventral recumbency) after a short period of pursuit by the male, or she may approach a male that is copulating with another female and adopt the prone position. Some receptive females may occasionally display mounting behavior with other females of the herd, although such behavior is much less common than in cattle. If the female is nonreceptive, rejection is shown by running away and spitting at the male. Males will attempt to mount receptive or nonreceptive females; their initial approach is indiscriminant. During mating, the male makes blowing, humming, nasal sounds. Copulation takes place in a recumbent position, with the male mounted above and just behind the female, and is remarkably prolonged (10 to 50 minutes).

FOLLICULAR DYNAMICS

As induced ovulators, three naturally occurring reproductive statuses exist in llamas and alpacas: 1) nonovulatory, 2) ovulatory but not pregnant, and 3) pregnant. Ovarian follicle development follows a wave-like pattern regardless of reproductive status (nonovulatory, ovulatory nonpregnant, or pregnant) or lactational status (lactating, non-lactating). That is, a group of follicles begins to grow synchronously, one of which continues to grow and become dominant while the others (subordinates) grow for a short period and then regress. If ovulation is not induced, the dominant follicle eventually regresses as well, and a new wave emerges so that the ovarian "cycle" repeats itself. The interval between emergence of successive waves of follicles is15 to 20 days. Maximum diameter of nonovulatory dominant follicles ranged from 9 to 16 mm and was greater, on average, in nonpregnant animals (12 mm) than in pregnant animals (10 mm).Dominant follicles of successive waves are equally as likely to develop in the ipsilateral as contralateral ovary; i.e., they do not regularly alternate between ovaries.

Ovulation

Female llamas and alpacas ovulate only after copulation, or after the administration of hormones with LH-like activity. Early studies suggested that the mechanical stimulation of copulation (penile intromission, treading and clasping of the male's legs on the back and sides of the female, and gutteral humming sounds emitted by the male) was responsible for inducing ovulation. However, recent studies have documented an ovulation-inducing factor (OIF) in seminal plasma. Circulating concentrations of LH start to rise 15 minutes after copulation, peak at approximately2 to 4 hours, and decrease to basal values by 6 hours after copulation. The interval from mating (or GnRH or LH treatment) to ovulation is 30.0 ± 0.5 hours. The mean diameter of the ovulatory follicle on the day before ovulation is 10 mm (range, 7 to 14 mm). Females with small follicles (4-5 mm) or regressing dominant follicles will not ovulate after copulation, whereas females with follicles ≥7mm and in the growing phase will ovulate after copulation. Ovulation failure occurs in 5% to10% of females with mature follicles, and the incidence of spontaneous ovulation is 4-8%.

Luteal Dynamics

Maximum CL diameter and plasma progesterone concentration occur at day 8 after mating (day 0 = mating). Luteolysis in non-pregnant females begins by day 10, and is complete by day 14. Luteolysis is associated with pulsatile release of $PGF_{2\alpha}$ from the uterus around days 8 to 10 after mating. Luteal diameter and plasma progesterone in pregnant animals continue to increase until maximum on about days 25. It should be remembered that progesterone indicates the presence of a functional CL, but it does not necessarily indicate pregnancy. Elevated concentrations of serum progesterone (>2 ng/ml) or urinary PdG (>1.5 ng/mg Cr) at 7 days after mating are only an indication of ovulation. Serum progesterone concentrations of >1 ng/ml at 21 days after mating are only an indirect indication of pregnancy.

Ovarian Irregularities

From examinations of reproductive tracts of animals sent to slaughter, about 15% of females exhibit some reproductive abnormality. Ovarian hypoplasia was the most common ovarian anomaly recorded and is characterized by small ovaries (1 x 1.5 cm) and absence of follicular development. The existence of a condition similar to cystic ovarian degeneration, as described in cattle, remains equivocal in camelids. It appears that "cystic" follicles in llamas and alpacas, previously defined as any follicle ≥12 mm, may have been over-diagnosed and over-treated in the past. Based on ultrasound studies, the mean (± sem) maximum diameter of the dominant follicle is 12.1±0.4 mm, and the range extends to 16 mm. However, females that are not exposed to a male (i.e., no sexual stimulation) frequently (16% of nonovulatory follicles) develop oversized follicles (≥ 25 mm in diameter. These oversized follicles were found to contain bloody fluid and were, therefore, termed **hemorrhagic follicles**. Hemorrhagic follicles may become very large (up to 35 mm) and persist for a prolonged period (weeks); however, they resolve spontaneously and do not disrupt ovarian function. Hemorrhagic follicles are not associated with infertility and treatment is not necessary. Primary ovulation failure has been reported in females that have apparent normal follicle development but do not ovulate after repeated copulation. The condition has not been systematically studied, but attempts to overcome this condition by natural mating or GnRH treatment have been unsuccessful; administration of LH or hCG at the proper time may be more effective.

Breeding Schemes

Pasture breeding (one or more males with a group of females) is commonplace in South America. In some Peruvian pasture breeding programs, males are maintained at only 3% of the herd (one male per 33 females) and replaced by new males every week (**alternating** or **rotary** system). Up to 18 copulations per day are possible by males, particularly on the first day of presentation to females. In a modified form of pasture breeding, the males are removed after 7 to14 days and reintroduction 14 to 21 days later. Females that refuse mating after reintroduction are examined for pregnancy (e.g., by transrectal ultrasonography). Modified pasture breeding programs allow more accurate record keeping and more rapid identification of problem animals. Individual, or hand-breeding requires the most intense management, and if carried out properly, yields very high reproductive performance.

An advantage of individual breeding is early identification of females with reproductive problems. Males may be presented in-hand or set free in a paddock with an individual female. A receptive female will usually 'cush' (assume sternal recumbency) quickly; however, behavior may vary considerably depending on age, experience, and relative dominance of the male and female. This 'teasing' procedure may be repeated daily to weekly until mating occurs. Teasing should be repeated at 1 week and again at 2 weeks after mating, and if receptive, the female may be mated again. Females that continue to breed over 3 such breeding cycles should be examined for abnormalities. Ultrasonographic examination of the reproductive tract enhances success of a hand-breeding program, particularly if this information is correlated with teasing.

Puberty and the Postpartum Period

Onset of puberty ranges from as young as 10 months of age to 3 years of age, but a general rule of 65% of projected mature adult weight is often used as a guide. Most females are first bred between 12 and 18 months. To maintain an annual birthing rate, female llamas and alpacas must become pregnant within about 20 days of birthing (gestation length, 345 days). The female is submissive immediately after birthing and will readily permit mating (apparent receptivity) up to 4 days after parturition. However, follicular growth and uterine involution are not sufficient and the female will not ovulate and is at risk of uterine infection from such early matings. By 10 days postpartum, the diameter of the largest follicle is about 8 to 10 mm, and the uterus has involuted substantially. Assuming a normal puerperium, mating of females within 15 to 20 days after birthing is recommended.

Synchronization and Fixed-Time Breeding

At any given time, one may expect to find a follicle of $\geq$ 6 mm in one of the ovaries, but to determine whether the follicle is growing (viable) or regressing (dying) would require more than one examination. Such a determination is of importance for breeding management since an immature follicle (<6 mm) or over-mature (regressing) follicle are not be capable of ovulation subsequent to copulation. In a recent study on ovarian synchronization, the effects of treatment with estradiol plus progesterone, LH, or ultrasound-guided follicular ablation, were compared by monitoring follicular wave dynamics, ovulation, and pregnancy rate after fixed-time natural mating. The interval from treatment to the day on which the new dominant follicle reached 7 mm(large enough to ovulate) did not differ between the LH and follicle ablation groups (5.2±0.5 days and 5.0±0.5 days, respectively), but both were shorter and less variable than in the control group (8.4±2.0 days), while the E/P group (7.7±0.5 days) was intermediate. Ovulation rates after a single, fixed-time natural mating 10 to 12 days after treatment did not differ among groups, but the pregnancy rate was higher for synchronized llamas (76%) than for non-synchronized llamas (54%). The results clearly demonstrate that follicular wave emergence can be induced electively, and animals can be synchronized sufficiently to permit fixed-time insemination without the necessity of testing behavioral receptivity. Treatment with LH (e.g., 5 mg Lutropin) or GnRH (e.g., 50 µg Cystorelin) 10 days before intended insemination is a simple and effective way to synchronize llamas and alpacas for pre-scheduled breeding management.

In females with a CL, treatment with prostaglandin is an effective in inducing luteolysis and a return to sexual receptivity. Although dose and timing of prostaglandin treatment has not been systematically examined, luteolysis has been induced with 100 µg cloprostenol i.m. in alpacas and 250 µg cloprostenol i.m. in llamas, given more than 4 days after ovulation. The CL of pregnancy may be somewhat more resistant to prostaglandin, but luteolysis and abortion can be effectively induced at any stage of pregnancy with 2 to 4 injections of cloprostenol. Prostaglandin $F_{2\alpha}$ toxicity and death have been reported in llamas following intramuscular use of dinoprost tromethamine, but no adverse reactions have been reported with fluprostenol or cloprostenol.

Summary

Llamas and alpacas have unique reproductive characteristics that differ markedly from other domestic livestock. They are induced ovulators and the ovarian cycle may be conveniently divided into follicular and luteal phases. Follicular waves develop at regular intervals regardless of reproductive or lactational status. The dominant follicle of each wave is anovulatory unless anovulatory stimulus is provided. An ovulation-inducing factor (OIF) in seminal plasma triggers LH release from the pituitary within 2 hours of mating followed by ovulation at 30 hours. It appears that a single stimulus is enough to provoke ovulation in the presence of an ovulatory sized follicle. Circulating progesterone concentrations are correlated with ultrasonographically detected CL diameter. In nonpregnant females, luteolysis begins by day 10 after mating and is complete by day 14, whereas in pregnant females, the CL is maintained throughout gestation. Based on endogenous ovarian patterns, effective protocols have been developed to synchronize follicular waves for fixed-time mating.

SPEAKER INFORMATION

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