Reproductive Physiology and Behaviour

Male Reproduction

Male Reproductive Organs.

Testicles. In an adult *alpaca* or *llama*, the testicles are found in a non-pendulant scrotum, without a defined neck, and forming a sub-anal protuberance, comparable to swine and rodents. The average weight of a fully developed *alpaca* testicle is approximately 15 gr (at five years of age, a male is considered to have reached full development with an average body weight of 62.5 kg). Measurements of a few adult male *llama* testicles are as follows: length 5 to 7 cm, width 2.5 to 3.5 cm, and depth 3 to 4 cm. In *llamas* weighing 133 kg, the average weight of each testicle is about 24 gr (n=24). Considerable variations occur in testicle size and live weight. The weight of each testicle will vary between 0.02 and 0.03 per cent of the body weight.

In *alpacas*, testicle size will vary between four and five cm in length and 2.5 to 3.0cm in width. At birth, the testicles are found in the scrotum, being small and flaccid. At one year of age, usually the time to select future sires, both testicles should be in the scrotal sacs (1.10-1.38cm long). Sires are selected by testicle size, on the assumption of the direct relationship between testicle size and sperm production seen in other species.

The testicles in the *llama* and *alpaca* are small and elliptical, located in such a way that the major diameter is oblique with a dorsal and caudal orientation. Normally, both testicles are of the same size, firm but not hard with a free movement inside the scrotum. The epididymis is firmly connected to the testes, being small and conspicuous. The deferent duct is very thin (2mm) at its beginning, thickens (3 to 4mm) when it reaches the abdominal cavity, and ends near the bladder, forming what in other species is the ampulla deferens, without the characteristics of this structure. The total length of the deferent duct is approximately 40cm. The microscopic characteristics of the testicles and epididymis are essentially the same as for other livestock species.

Accessory Sexual Glands. The prostate is H-shaped, lying dorsally and laterally above the neck of the bladder. The bulbourethral glands are oval, located at the sides of the urethra in the pelvic outlet. SACs do not have seminal vesicles.

Penis and Prepuce. The penis is fibroelastic, with its end in the form of a curved hook to the right, with a small "urethral process" of one centimetre in length. The size of the erect penis is 35 to 40cm and the sigmoid flexure is pre-scrotal. The prepuce of the lamoid is triangular and non-pendant. In an unaroused male, the prepuce is directed caudally, and urine is projected backwards between the hind limbs from a semi-squatting position. When the male is sexually aroused, the cranial preputial muscles pull the prepuce cranially and the penis is extruded in the same manner as in the bull, between the hind legs.

Puberty. At birth, the penis is completely adherent to the prepuce. The adherences disappear gradually along with the growth of the animal under the influence of testosterone. At one year of age, the males show sexual interest in the females; however, only about eight per cent of the males show a complete liberation of the penis-prepuce adherences and are capable of copulation. At two years of age, approximately 70 per cent of the males have a liberation of the adherences, and 100 per cent at three years. Precocious behaviour and early mating are considered to be desirable traits in genetic selection programmes. Future sires are those that do not have prepuce-penis adherences as yearlings. However, the general practice is to use three year old males for reproduction.

Sexual Behaviour. Field observations have shown a *sui generis* behaviour of the *alpaca*. The male begins courting by running behind the female whether or not she is in heat. If the female is in heat, she will let the male mount her and adopt a seated position. Copulation will last for five to 50 minutes. During copulation, the male makes a guttural sound, in contrast to the female who remains submissive. Sometimes females will seat themselves next to a mating couple as a sign of also being in heat. At the beginning of the breeding season, when the males first join the females, the males show intense sexual activity, copulating up to 18 times per day. Recent studies indicate that the deposition of semen during normal copulation, is intrauterine.

Semen Collection. Collection of semen in SACs is complicated by the position of the mating animals and the long time of copulation. The first reported collection of semen was carried out using artificial vaginal sleeves which were recovered after copulation. Later on, vaginal pessaries, or sponges, were utilised, and it was reported that 20 per cent of the males did not have spermatozoa. However, both forms of semen collection are questionable, since they interfere with normal copulation and contaminate the semen. Also, in both studies, the volume of semen ejaculated was highly variable, fluctuating between 0.4 and 6.6 ml.

The use of the electroejaculator seems to be the most adequate means of semen collection. Nevertheless, during the electrical stimulus, the semen could be contaminated with urine and its quality is variable, with sperm concentration fluctuating between 1,000 and 255,000/mm^3.

More recently, the use of an artificial vagina (AV) has been reported. The AV was inserted inside an *alpaca* dummy in sitting position, obtaining up to 12.5ml of high quality semen with very good motility and around 500,000 sperms/mm^3. The semen of the *alpaca* or *llama* is highly viscous, causing difficulties in the separation of spermatozoa from the seminal plasma and hence estimation of sperm concentration by conventional methods. Due to the high viscosity of the seminal plasma, sperm motility is slow compared to that of other domestic species. Experimental evidence with the use of urethral fistula and artificial vagina indicates that ejaculation is a continuous process, with a uniform semen quality from the beginning to the end of copulation. Likewise, deposition of semen is intrauterine.

Female Reproduction

Female Reproductive Organs.

Ovaries. The ovaries are of globular, irregular shape, similar to those of the sow, particularly when they have multiple follicles. The left ovary in the *alpaca* is slightly heavier (2.40 $\pm$ 1.34g) than the right (1.87 $\pm$ 0.94 g) when neither has an active corpus luteum. The dimensions are: length, 1.64 $\pm$ 0.33 cm width, 1.07 $\pm$ 0.18 cm. Follicles are of five mm or bigger and the corpus luteum are prominent and conspicuous. Follicles between five and 12mm are normal and anything bigger than these dimensions can be considered pathological.

Oviduct, Uterus, and Vagina. Both oviducts are long and tortuous (length 20.0 $\pm$ 4.16cm), ending in a bursa which totally covers the ovary. The uterus in the *alpaca* and *llama* is bicornuate, with two uterine horns separated by a septum. The length of the left horn is slightly greater (7.89 $\pm$ 1.28cm) than the right (7.39 $\pm$ 0.98cm). The width of the uterus is relatively small (3.05 $\pm$ 0.71cm) and the cervix has two to three rings. In some ways, the uterus of the *alpaca* is similar to that of the ewe, although in the case of the ewe, the uterine horns become thinner nearer the utero-tubal junction. Both sides of the uterus are attached to the abdominal and pelvic walls by a wide ligament.

The isthmus of the oviduct enters the uterine horns in the shape of a small papilla, acting as a well-defined sphincter. The vagina has an approximate length of 13.37 $\pm$ 2.00cm, and a diameter of approximately 3.35 $\pm$ 0.67cm.

Puberty. Young female *alpacas* of 12 to 13 months show oestrous behaviour similar to that of adult *alpacas*. The majority of females show sexual receptivity at 12 months of age, even though ovarian activity begins at 10 months, with the presence of follicles of 5mm or more.

In a study carried out in southern Peru to evaluate the effect of body weight during the breeding season, on reproductive performance in 280 female yearling *alpacas*, it was determined that a highly significant ($P < 0.001$) relationship existed between body weight at the time of mating and subsequent rates. For each kilogramme in excess, there was a five per cent increase in natality; but when body weight exceeded 33kg, the percentage of open females was relatively independent of body weight. Under present management and breeding systems in South America, 50 per cent or less of yearling *alpacas* reach 33kg of liveweight at mating time. In other domestic animals, puberty is genetically determined and is modulated by environmental factors, nutritional levels being one of the most important. It has been shown that with better nutrition after weaning (7 to 8 months), almost 100 per cent of yearling *alpacas* can reach 33kg.

In South American traditional production systems, the female *alpaca* and *llama* are bred every two to three years, reflecting inadequate nutrition and management. For the *llama*, it is generally recommended not to breed a female before she has reached two-thirds of her anticipated adult body weight (102 to 109kg). In the USA, some *llama* breeders claimed that the actual time of puberty varies from six to 24 months, being related to both nutritional status and age.

Breeding and Birthing Season. Since SACs have a gestation period of 345 days on average, birthing seasons and breeding seasons can coincide. Studies of the *alpaca* and *llama* in their natural habit in the highlands of the Andean Region showed that the breeding season lasts from December to March (summer months). These are the warmest months, with sufficient rain and abundant green forage. In most of the herds, where males and females are together all year, i.e., the herds in peasant communities, parturition occurs only in the summer months, indicating a seasonal mating period. Wild species such as the *vicuna* and *guanaco* also have a seasonal breeding period. However, when females are kept separate from males and copulation is allowed only once a month, both sexes are sexually active during the entire year. Ovulation and fertilisation rates, along with embryo survival, were not significantly affected by the season of the year.

Experimental observations show that the continuous association of females and males inhibits sexual activity of the latter and even causes it to disappear altogether. Factors responsible for the onset and cessation of sexual activity under natural conditions are unknown. Environmental factors, in addition to visual and olfactory stimulation, could influence sexual activity via the central nervous system. It is well documented that the effect of external stimulation on sexual behaviour is more pronounced in the male than in the female. A mating system has been developed for the *alpaca* and *llama*, changing the breeding males each week for another group of males (during 60 days), enhancing the mating rate in the herd and, consequently increasing the natality rate. Observations in different zoological parks of the world indicate that lamoids are year-round breeders, but with a higher parturition rate during the summer months of each particular region.

Normal Ovarian Activity in Unmated Females. The female *alpaca* and *llama* do not have oestrous cycles like other large domestic species; oestrus and ovulation are not repetitive, cyclic, and predictable.

When unexposed to a male the female *alpaca* shows long periods of sexual receptivity, up to 36 days, with short periods of rejection of the male that could last for two days. Studies of the duration and periodicity of oestrus in the *alpaca* suggest that there is considerable variability between individuals, regardless of the reproductive status (parous vs. non-parous). The variability that exists in both the duration of oestrus and regularity of its occurrence presumably reflects the fact that in unmated females,

the follicular phase is not terminated by ovulation at a predetermined time, and that there is no luteal phase to delineate the timing of events after the end of oestrus.

The long periods of sexual receptivity and short periods of non-receptivity have not been very well documented, nor are they clearly delineated. However, these periods may be correlated with rhythmic increases and decreases in serum oestrogen levels. Based on laparoscopic examination of *alpaca* ovaries at different intervals, the growth, maintenance, and regression of a follicle each required an average of four days with a total of 12 days (range from nine to 17 days).

Oestrous and Mating Behaviour. The female *llama* and *alpaca* do not exhibit common outward signs of heat or receptivity. The receptive female adopts a special pattern of behaviour in the presence of the male; she may take the prone position when the male is approaching her, or approach a male that is copulating with another female and adopt the prone position. In other cases, the male pursues the female for a short time, then mounts her and finally the female takes the prone position. It is also common to see some receptive females mounting other females of the herd. If the female is non-receptive, rejection is shown by running away from and spitting at the male.

Ovulation. Since copulation is ordinarily a necessary prelude to ovulation, the *alpaca* and *llama* have been classified as **reflex** or induced ovulators, as opposed to spontaneous ovulators. The same mechanisms have been found in Old World Camels.

The minimum time from copulation to ovulation has been estimated to be 26 hours following natural mating and 24 hours after injection of HCG (500-700 IU, im). Based on laparoscopic examination, 48.8 per cent ovulated between 26 to 30h, 28.8 per cent ovulated between 30 to 72h, and 22.5 per cent failed to ovulate; yearling *alpacas* accounted for most of the failures to ovulate. Investigation on the *llama* using an ultrasonographic technique revealed that ovulation occurred, on average, two days after a single mating. Ovulation was also successfully induced using one mg of luteinising hormone; a dose of four to eight micrograms of GnRH was also necessary to provide the adequate stimulus for ovulation.

There are some indications that females can ovulate without coital or exogenous hormonal stimulis especially when initially isolated from, and then exposed to, a male, but without allowing intromission. Spontaneous ovulations have occurred in 10 to 42 per cent of the *alpaca* females exposed to males, especially during the height of the breeding season. In the USA, five per cent of spontaneous ovulation has been reported. It has also been shown that both *alpaca* and bull semen can induce ovulation in *alpacas* and *llamas*, provided the semen is introduced deep into the vagina of a receptive female.

Multiple ovulations occurred in three to 10 per cent of *alpacas* after natural mating and in nine to 20 per cent after application of gonadotrophins, but twins born alive are extremely rare. The ovulatory activity, indicated by the presence of a corpus luteum of pregnancy, was always in favour of the right ovary. However, the magnitude of the difference varied in several studies.

Corpus Luteum Formation and Function. Corpus Luteum (CL) function was studied in non-pregnant *alpacas* after sterile matings and in pregnant *alpacas* after fertilising services. *Alpacas* or *llamas* mated with a vasectomised male (sterile) will form a functional CL. Progesterone (P4) was secreted from day five and reached maximum concentration of 10 to 20 nmol/L on day seven to eight. A rapid decline in P4 levels occurred on days nine to 10 in connection with repeated surge releases of protaglandins F2 alpha. Oestriol levels were > 100 to 200 pmol/L during receptivity when the females were mated and stayed low, 20 to 40 pmol/L during the luteal phase, but rose in most animals after luteolysis to 40 to 60 pmol/L. Additional observations suggest that during three to four days after coitus, when P4 concentrations remain low, and the CL is being formed, female *alpacas* and *llamas* could be receptive to the male.

In most cases, a fertile mating results in the formation of a CL of pregnancy which secretes P4 throughout the gestation period. P4 levels of 16 to 17 nmol/L were found on the ninth day after mating, with levels of 16 to 18 mol/L on the sixteenth day, remaining more or less constant until 30 days of pregnancy.

Pregnancy. The length of gestation in *alpacas* of the *Huacaya* and *Suri* breeds has been quoted as 341 and 345 days respectively. For *llama* in the USA, an average of 344 days, with a wide range (331-347 days), was given. In another study in Peru, with 79 nulliparous and 61 pluriparous animals, where only two matings were allowed (at six to eight hours interval), and the day of parturition registered, the gestation length was 346 $\pm$ 8 days (range 327-357), with no differences between nulliparous and multiparous or sex of the *cria* (litter).

Almost all *alpaca* and *llama* foetuses were found to be implanted in the left uterine horn, even though both ovaries are active to an equal degree. This indicates that embryos originating in the right side migrate to the left horn in order to survive. Migration provides a mechanism for embryonic survival by avoiding the right uterine horn which appears to be inadequate for embryo development.

As we said previously, multiple ovulations occur in the *alpaca* and *llama*, but twins born alive are extremely rare. Cases of twin pregnancies are only occasionally seen in the early stages of gestation. Various authors reported the presence of live twin embryos 31, 38, and 40 days after mating, both located in the left horn. The embryo located in the right uterine horn was dead. One *alpaca* twin birth in Peru and two *llama* twin births in the USA, have been reported.

The role of the CL during pregnancy indicated that the CL is necessary for the maintenance of pregnancy during the entire gestation period in the *alpaca* and *llama*, and, thus, these species can be classified according to the source of P4 as CL-dependent, similar to the cow, goat, and sow.

Fertility Rates and Embryonic Mortality. During the first month, embryo mortality appears higher in *alpacas* than in other domestic species, and seems to be a serious reproductive problem. In a study carried out in Peru, only 50 per cent of the fertilised ova survived for more than 30 days of gestation. Another study suggests that the overall reproductive wastage in *alpaca* (ova, embryo, and foetal loss) was 83.2 per cent , based on the number of pregnancies occurring 30 days after mating. No embryo-foetal losses were found from 90 days after mating to term. The factors responsible for this high rate of embryonic mortality have not been identified, but low nutritional levels can cause this problem.

Diagnosis of Pregnancy. In the traditional system, pregnancy is diagnosed by external palpation (ballottement) at eight months, a process at which most herdsmen are highly skilled, but this is very late for good reproductive management of the herds.

The behavioural response of females in the presence of males has been described by several authors. Using vasectomised males and, without exception females that showed oestral behaviour four or more days after a previous service (mating) were not found to be pregnant. Also, all pregnant females rejected the males between 20 and 95 days of pregnancy. However, not all of the females that rejected males were found to be pregnant. In another study, using teaser males (vasectomised), it was found that the accuracy of pregnancy diagnosis through oestral detection in the *alpaca*, on the 70th and 125th days after mating, was 84 and 88 per cent respectively; and in the *llama*, 85 and 95 per cent accuracy was obtained at foetal ages of 75 and 125 days after mating. The accuracy of pregnancy diagnosis obtained for *alpacas* and *llamas* in this study (84 to 95%) on the 70th to the 125th day of gestation is comparable to the accuracy obtained in a study on sheep. Therefore, oestral behaviour has been shown to have moderate accuracy. The date of breeding is required if used very early after mating and is limited to the extent that non-pregnant females do not always show oestrous and some females allow mounting during luteal function,

especially if the teaser male is heavy, big, and aggressive. This technique requires a good knowledge of the sexual behaviour of lamoids as well as careful observation. It has not been widely adopted to date.

Pregnancy diagnosis by rectal palpation has been reported to be possible as early as on the 30th day of gestation but is limited because of pelvic size, particularly in younger and small animals. In a medium-sized herd of *alpacas* and *llamas*, with good nutrition and management, 70 per cent of the yearlings and 90 per cent of the adult *alpacas* were palpated, as well as 100 per cent of all *llamas*. However, the accuracy of pregnancy diagnosis by rectal palpation on the 165th day after mating was 100 per cent ; however, it was impossible to palpate 18 per cent of the *alpacas* due to pelvic anatomy, fat deposition in the pelvic inlet, and size limitations.

Milk and blood progesterones were used for pregnancy diagnosis in the *alpacas* and *llamas*. A striking difference in milk P4 concentrations between non-pregnant and pregnant *alpacas* was observed on the 12th day after mating, from which it was suggested that this difference might furnish the basis for an early pregnancy test.

Plasma P4 changes during the first 30 days of pregnancy in the *alpacas* and *llamas* have been described as a method for early pregnancy diagnosis, as well as during the gestation period. P4 concentrations below six nmol/L indicated non-pregnancy status. Detection of a fluid-filled uterus, using an ultrasonic device (Ithaco Ultrasonic Scanopreg, Model 738, Ithaca, NY, USA), developed for sheep, has been used in *alpacas* and *llamas*. The equipment is recommended for use from 60 to 120 days of pregnancy. The transducer was placed on the hairless abdominal wall, three to five cm cranial to the right udder; in *alpacas*, the highest accuracy of 92 per cent was recorded at a mean foetal age of 80 days compared to 90 per cent at 70 days of gestation. In *llamas*, 100 per cent accuracy was obtained at 75 days of gestation; in both species, the accuracy of the test was reduced to 84 per cent and 65 per cent at 165 days of gestation in the *alpaca* and *llama* respectively.

Also, in recent years, transrectal ultrasonography (B-Mode) has been used in domestic SACs. With this method, pregnancies were detected as early as 15 days after mating, but 100 per cent accuracy was obtained at 25 days after mating; they used a five MHz probe and a linear array scanner (ALOKA, Japan).

Parturition. Births in *alpacas* occur only during the early hours of the day. No births occur between 17.00 hours and 04.00 hours (unless there is an emergency), the time when temperatures are low even in the summer (and also throughout the year at altitudes higher than 4,000m). In *llamas*, 87 per cent of all parturitions also occur in the morning hours and a few cases in the early afternoon, giving the young a chance to get warm and dry before the cold nights.

In the *alpaca*, unassisted labour lasted, on the average, from 193 $\pm$ 122 minutes and 203 $\pm$ 129 minutes for multiparous and primiparous females respectively. In the *llama*, it lasted a mean of 176.3 minutes for all the stages of labour. The *alpaca* and *llama* do not lick their offspring at birth, even given a poor nutritional status.

Postpartum Period. Up to the fourth day after parturition, the female *alpaca* is submissive and can be mounted by the male. However, she is not fertile, since the regression of the CL, follicular growth, and the involution of the uterus, are prerequisites to renewed sexual activity. Five days after giving birth, some females show acceptance of males and, following copulation, occasionally ovulation and fertilisation occur. Ten days after childbirth, the follicles are eight to 10 mm in size (the ovulatory size), the CL has regressed considerably, and the uterus involuted, weighing only a fifth of its weight, 24 hours after birth. Mating of females is recommended within 15 to 20 days after giving birth in order to obtain good fertility rates and one offspring a year.

The placenta in the *alpaca*, as in other camelids, is diffuse and epitheliochorial in type. The existence of a unique extra-foetal membrane, which encases the entire foetal body and appears to be an epidermal product from the basal layers of the epidermis, has been described in the four SAC species.

Artificial Insemination and Embryo Transfer. Several studies have been made on the feasibility of artificial insemination in *alpacas* and *llamas*, as well as some inter-species' crosses. Semen from males was obtained by electroejaculation or by artificial vagina. The most appropiate time for insemination after ovulation, induced either by vasectomised males or 1,500 IU of hCG, occurred 35-45 hours following mating or hormone treatment.

One study done at the High Altitude Research Station "*La Raya*", Cusco, Peru, reported the natality rates of different inter-species crosses. Six *llamas* were each inseminated with 0.5-1.0 ml of fresh *vicuna* semen,collected by electroejaculation, and one offspring was obtained (16.7 % natality rate); nine *alpacas* were inseminated with *vicuna* semen, and two offspring were obtained (22.2 %). When *paco-vicuna* semen was used for insemination, three hybrids were obtained after inseminating five *llamas* (60%), and 23 hybrids were obtained after inseminating 74 *alpacas* (31.1 %). In this study, insemination was performed using the rectal palpation technique and best results were obtained by using 700 IU of hCG for inducing ovulation.

It is necessary to note that the SACs offer advantages over other domestic species in the use of artificial insemination. Since females have no oestral cycles and are induced ovulators, showing more or less continuous oestral behaviour during the breeding season, ovulation can be induced with a vasectomised male or with exogenous hormones, and the insemination can be intrauterine into the left horn independent of the ovary containing the CL.

Embryo transfer has been conducted in *alpacas* and *llamas*. In the first research trial with *alpacas*, in the early 1970s, the embryos were collected by surgery and flushing took place from the oviduct towards the horn of the uterus. It is impossible to pass fluids from the uterus to the oviduct, as in sheep, due to a papilla in the utero-tubal junction projecting into the uterine lumen with a valve-like action. At that time, the natality rate was 10 per cent. There is a report from the USA about non-surgical embryo transfer, where two donor female *llamas* were flushed and one viable seven-day old embryo was recovered and transferred within four hours into a recipient female *llama* whose oestrus was synchronised with the donor by injecting GnRH. A normal and healthy male was born 326 days after transfer.

Hereditary and Congenital Abnormalities in Alpacas and Llamas

In recent years, increasing interest has been shown in the losses caused by congenital and hereditary malformations in *alpacas* and *llamas*. Observations in Peru, Bolivia, Chile, and the USA show that it is necessary and urgent to focus attention on the development conditions that cause economic losses by decreasing reproductive capacity, reducing fertility, increasing prenatal mortality, creating obstetrical problems, and diminishing the value of the viable defective *crias* and their relatives. However, it seems that most congenital or hereditary disorders are usually disregarded or are observed only with curiosity or passive interest.

Congenital defects in domestic SACs are undoubtedly more common than indicated by the few reports in the literature, and all the abnormalities described here were observed during investigations carried out during the last 25 years in the most important breeding area of Peru.

Many defective *alpaca* or *llama cria* are not observed, because of the prevalent animal husbandry practices in Peru, where there are very few veterinary practitioners. Therefore, it is difficult to assess the frequency of congenital diseases in SACs.

When a defective *cria* is born, the problem is whether the cause is genetic or environmental; in addition, it is often impossible to identify the father of a defective *cria*, due to the breeding system prevalent in large or small herds kept by peasants in the Andean countries. Other factors are the lack of knowledge of the breeders or veterinary practitioners in teratology; the lack of historical and other records, and (what I found to be very common among the most important *alpaca* breeders) hiding the defective *cria* for economic and prestige reasons.

Although more than 44 congenital diseases in domestic SACs have been identified, there is no information on the majority of these disorders. Many more defects probably exist that require more research and field studies. The breeders should have programmes for reporting, recording, and monitoring undesirable genetic traits.

None of the conditions that we are going to mention are conclusively proven to be hereditary; furthermore, we do not know about the environmental factors or teratogens that cause defective *crias*. Proof of a hereditary defect must be obtained carefully and meticulously. Genetic defects are pathophysiological results of mutant genes or chromosomal aberrations; genetic defects are recognised only when they occur in characteristic, intragenerational familial frequencies and intragenerational patterns. Although chromosomal aberrations have been observed in domestic animals for some time, chromosomal scanning is not routinely carried out, but we should encourage examination of chromosomes in live defective *crias*. In the case of environmental factors, few have been considered as teratogenic in domestic animals, and, in general, do not follow familial patterns but rather seasonal patterns or known or suspected maternal stress.

Ingestion of some plant teratogens, viruses, mineral deficiencies (especially iodine), hyperthermia, agricultural and veterinary drugs, irradiations, and maternal age have been suspected of being teratogenic in domestic animals. Meanwhile, almost all the defects in *llamas* and *alpacas* should be considered inherited until proven otherwise.

With the increasing growth of *llama* and *alpaca* breeding in the Andean Region, as well as their export to other continents and countries, it is probable that some inherited diseases may become widespread, if indiscriminate breeding takes place without a system to monitor and control inherited defects. Breeders need to consider that any element of "inbreeding", whether knowingly or unknowingly practised, will concentrate undesirable genes in the population and so tend to increase the frequency of genetically-induced disease.

Congenital defects may be lethal, semi-lethal, or non-lethal and they are usually classified by the body system that is primarily affected. The most frequently encountered congenital defects in *alpacas* and *llamas* involve the reproductive, appendicular, and facial skeletal systems, and the most common specific abnormalities are inferior prognathism (Brachignatia superior), polydactyly, craniofacial defects, cryptorchidism, testes hypoplasia, ovarian cysts, segmental aplasia of Mullerian ducts, etc.

The congenital defects reported in Peruvian and Chilean domestic SACs are given below, according to the principal body system involved.

Defects of the Facial Skeleton

Inferior prognathism
Superior prognathism
Cerebral hernia or "Catlin mark"
Choanal stenosis or stresia
Fused nasal openings or arrhinia
Cyclopia

Defects of the Axial Skeleton

Polydactyly
Syndactyly
Monobrachia
Peromelia

Defects of the Muscular System

Arthrogryposis

Defects of the Cerebrum

Hydrocephalus

Defects of the Intestinal System

Atresia ani

Defects of the Body Cavity

Umbilical hernia

Defects of the Male Reproductive System

Hypoplasia of the testes
Cryptorchidism
Aplasia of the testes
Cystic structures in the testes
Ectopia testes (a form of cryptorchidism)

Defects of the Female Reproductive System

Follicular cysts
Hypoplasia of the ovaries
Segmental aplasia of the uterine horn
Imperforate hymen
Uterus unicornus (with ipsilateral renal agenesis)
Dermoid cysts
Paraovarian cysts
Gartner cysts
Double cervix
Intersex
Polithelia
Hypoplasia of the mammary glands

Defects of the Sense Organs

Microtia
Anotia