How is male-factor subfertility minimized in companion and food-producing animals?

R.P. Amann

Introduction

Propagation of companion and food producing animals is primarily by planned use of sires known to transmit desired traits. Exclusion of males likely to be noticeably subfertile is also a goal. Use of superior sires is facilitated by artificial insemination (AI) (Chapter 25). AI predominates with dairy cattle and pigs, is popular with dogs and horses, but is banned for thoroughbred horses. Natural mating predominates with widely dispersed beef cattle and sheep. Few unselected dairy bulls have an observed pregnancy rate >8% below the national average, because for >15 generations bulls with inferior semen or low pregnancy rate have been culled before extensive use via AI. However, 1 in 5 unselected beef bulls might be subfertile.

Reproductive function

Species differences are superbly described and illustrated in Senger's text. Testes hang between the hind legs, except in pigs where they are below the anus. Stallions have an erectile penis, like a human, whereas bulls, boars and rams have a fibroelastic penis which straightens, from a non-erect S-shaped structure, on engorgement with blood. In the dog, an os penis allows intromission before complete vascular engorgement. Except for dogs, the complement of accessory sex glands is as in humans, i.e., seminal vesicles, prostate, and bulbourethral glands.

Spermatogenesis requires 39 to 61 days, depending on species. Daily sperm production per gram testis parenchyma (10^6) typically is 10–19 in bulls, dogs or stallions and 21–25 in boars or rams (contrasted to $4x10^6$ for men). Weight of a single testis might range from 8 to >700 grams (small dog; boar) and daily sperm production per male (10^9) ranges from near 0.4 for dogs; 5–8 for bulls, rams, and stallions; to 16 for boars (contrasted to 0.07–0.28 for men). Transit of sperm through the epididymal duct takes 7–17 days, with most of this interval spent within the cauda epididymidis. Paired caudae epididymides can accommodate sufficient sperm (3–130 $x10^9$) for a number of ejaculates. Frequent ejaculation reduces number of sperm in the caudae epididymides, by up to 50% when ≥10 ejaculations occur on 1 day. With no emission/ejaculation over 6–10 days, sperm "spill out" into the pelvic urethra and are voided with urine.

Endocrine regulation of reproductive function in male animals is similar to that described for men (Chapters 2,4,5,8). However, there are both diurnal and seasonal variations in pulsatile secretion of LH and testosterone. Seasonal variation is pronounced in rams and stallions, and sperm production declines 30–80% in the non-breeding season (fall and spring, respectively in northern latitudes). Photoperiod is the primary signal synchronizing an endogenous rhythm.

Semen collection

Examination of sperm is central in minimizing subfertility. Semen collection from most animals is easy using an artificial vagina (AV), masturbation, or electroejaculation (EE). Motility and morphology of sperm are not affected by method of semen collection. An AV is a cylinder, which contains warm water between the jacket and latex liner to provide warmth and slight pressure on an inserted penis, and an attached container to receive semen. An AV can be used with males of most species. The male is provided with a teaser animal or dummy and when he mounts the penis is directed into the AV allowing intromission and ejaculation. This approach usually provides a representative ejaculate. Semen from stallions and bulls usually is collected with an AV. With boars and dogs, penile pressure stimulates ejaculation. A male is allowed to mount an estrous female or phantom and the collector simply grasps the free end of the protruded penis to mimic the interior of a pig's cervix or a dog's vaginal vestibular muscles, applies necessary pressure, and directs semen into a receptacle. EE involves appropriate restraint of a male, transrectal placement of a probe with 3 longitudinal electrodes over adjacent nerves, and rhythmic application of mild electrical stimulation. This method is useful with bulls, rams, and wild animals. The resulting ejaculate usually is more dilute than one obtained using an AV.

Emission and ejaculation require only a few seconds in bulls and rams, or <1 minute in stallions. In boars and dogs the ejaculatory process is a minutes-long series of emissions and ejaculations, so it is common to direct only the sperm-rich fraction into the semen receptacle. For boars, bulls, dogs, rams, and stallions a spermatozoon has a paddle-shaped head with a compact acrosome over the rostral portion of the nucleus, under the plasma membrane. The shape of the head allows distinguishing sperm from one or another species.

Breeding-soundness examination

Owners of food-producing and companion animals know that most males will not be needed as sires, because one male can impregnate >25 females during a breeding season lasting 1–3 months (beef cattle, horses) or throughout a year (dairy cattle, dogs, pigs). Future sires are selected for genetic reasons and unselected males are castrated. After puberty, selected males usually are given an andrological or breeding soundness examination (BSE) by a veterinarian.

The goal of a BSE is to identify males likely to be subfertile, or for other reasons unsuitable for breeding, at the time of examination. Subfertile is a relative term, and for companion and food producing animals might be a male with relatively small testes or whose semen has more immotile or abnormally shaped sperm than desired. A BSE includes a history; complete physical examination; evaluation of the testes, epididymides, accessory sex glands, and penis; and collection and evaluation of semen. The number of sperm in an ejaculate (considering age and species) and the motion and morphologic characteristics of sperm collected can be diagnostic, especially if multiple samples are collected. Absence of sperm in an ejaculate does not mean the male is sterile, because occasionally emission of sperm from the excurrent ducts will not occur despite emission of accessory sex gland fluids which then are ejaculated.

In good quality semen, >70% of the sperm have a normal head shape, a non-swollen acrosome, no residual “droplet” of cytoplasm in the neck or annulus region, and have a normal looking tail. Especially with boars and bulls, specific morphologic defects have been linked with inability of a spermatozoon to fertilize an oocyte or to produce a normal embryo. In good quality semen, >60% of sperm should display progressive motion when examined in a diluted suspension at 37°C.

A male failing a BSE might pass a similar exam 1-6 months later. Passing a BSE often is a prerequisite for sale of a sire. A male passing a BSE likely will be of reasonable fertility, i.e., commercially useful, when mated with normal females. However, subsequent changes or factors not detected might depress his fertility. An example is lack of libido under range conditions, because a test of serving capacity is not part of a BSE and EE usually is used to obtain examined semen. Importantly, when a sire is used with a group of females the collective pregnancy rate will depend on female and management factors.

As breeding progresses, animal owners check females for pregnancy. If an owner suspects pregnancy rate is low in a natural mating situation, a veterinarian might be asked to perform a BSE on the male(s). This is a frequent occurrence with valuable stud dogs, stallions, or beef bulls. Then

Handbook of Andrology – How is male factor subfertility minimized in companion and food producing animals?

issues include: “Why is pregnancy rate, semen quality, or sexual behavior of this male poor?” and “What is the prognosis for improvement?” Usually, the passage of time (>2 months) is the most cost-effective therapy. Genetic companies monitor quality of semen prepared for sale, in an integral andrology laboratory, and also outcomes with semen sold for AI. They cease distribution of any male whose semen quality drops below their standards or with a pregnancy rate that seems low, e.g., ≥8 percentage units below average.

Factors associated with subfertility

Clinical problems in previously normal animals arise from several causes. Perhaps most common are heat and humidity. Heat affects many boars, bulls, and stallions. To avoid a “summer slump” in semen quality, i.e., decreased percentages of morphologically normal or motile sperm due to elevated intratesticular or cauda epididymal temperature, many breeders or genetics companies house valuable males in air-conditioned facilities. Rams are less affected because they are fall breeders and their testes are “ramping up” as ambient temperatures decline. Stud dogs usually are kenneled in cooler areas. Nevertheless, cases of oligozoospermia and increased numbers of morphologically abnormal cells consequent to heat-stress are seen. Cool temperatures usually are not a problem. Temperature-induced changes are diagnosed by history or BSE results. Therapy involves eliminating the causative factor and allowing 2-6 months for recovery.

Infectious agents are common problems, especially venereal diseases. Brucellosis is a venereal disease that causes epididymitis, orchitis and azoospermia in cattle, sheep and dogs. Affected animals should be euthanized. Other bacterial infections are common in stallions and stud dogs. White blood cells in semen cause suspicion and differential semen-culture-based tests identify the organism. Therapy is as indicated by sensitivity in culture.

Trauma is a common problem in free-ranging sires. Diagnose is easy and treatment involves surgical intervention or medical therapy. Parasitism and metabolic problems are uncommon, but can be diagnosed from history and clinical presentation which then guide medical treatment.

Summary

Male-factor subfertility is minimized by selection via andrological examinations and follow-up evaluations of ejaculate and sperm characteristics. Males with small testes or producing inferior semen, whose sperm display

sub-standard quality in laboratory evaluations, or whose semen does not provide a commercially useful pregnancy rate, are eliminated from a breeding program.

Suggested reading

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