

EJACULATION

Physiology and Dysfunction

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Copulation normally culminates with two physiologically distinct events known as emission and *ejaculation*.^{3, 30} *Emission* is the release of sperm and accessory gland fluids into the pelvic urethra. *Ejaculation* is the forceful expulsion of the combined fluids (i.e., semen) from the urethra. The associated perceptual-cognitive event called *orgasm* in humans has not been characterized in nonhuman species. The neurophysiologic correlates of *orgasm*³³ no doubt occur in animal species, so it is reasonable to posit that animals perceive some form of analogous satisfying perceptual resolution of copulation. This article begins with a brief outline of the physiology of emission and ejaculation followed by a discussion of related disorders in stallions.

PHYSIOLOGY

Emission during copulation follows a species-typical number and pattern of intravaginal thrusts. In stallions, seven to nine thrusts typically precede and, presumably, lead to the reflex of emission.¹² Figure 1 outlines the key events and innervation of erection, emission, and ejaculation as understood in horses. Emission consists of contraction of the smooth muscle walls of the caudae epididymides (epididymal tails), deferent ducts, ampullae, vesicular glands, prostate gland, and, possibly, bulbourethral glands, with resultant release of fluids and spermatozoa into the urethra. The bladder neck simultaneously contracts, keeping the urethral orifice of the bladder tightly closed. Emis-

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sion and bladder neck closure are primarily alpha-adrenergically mediated. The efferent aspect of the emission reflex involves preganglionic sympathetic fibers leaving the lumbosacral segment of the spinal cord, with principal connections in the caudal mesenteric plexus en route to the tubular genitalia. Ejaculation, the forceful expulsion of semen from the urethra, results from rhythmic contractions of the ischiocavernosus, bulbospongiosus, urethralis, and other striated pelvic muscles. Simultaneously, the anal sphincter contracts rhythmically. In the stallion, ejaculation occurs as five to ten jets of semen, each subsequent jet expelled with decreasing pressure, volume, and sperm concentration.^{8, 32} During ejaculation, the stallion's tail waves (termed flagging) with each ejaculatory pulse. The reflex of ejaculation is mediated via the pudendal nerve and sacral segment at the spinal cord. It appears that the emission process precedes and plays a role in triggering the ejaculatory reflex.

Emission and ejaculation also occur without copulation, either spontaneously or during self-stimulation, in most mammalian species studied. Men and other primates emit semen while sleeping. This is known as nocturnal emission. Dogs and rodents emit semen on a daily basis, detected as seminal plugs. Stallions exhibit spontaneous erection and movements of the penis called masturbation. Masturbation episodes normally occur at approximately 90-minute intervals in undisturbed horses.^{13, 17} However, spontaneous emission or ejaculation of semen appears to be relatively infrequent in all horses studied.¹³

DYSFUNCTION

Specific ejaculatory dysfunction in animals has been defined as ejaculatory disturbance in spite of otherwise normal sexual behavior. In our equine fertility clinic, roughly one quarter of the reproductive behavior cases and consultations have been referred for evaluation of ejaculatory dysfunction (62 of 250 stallion behavior cases reviewed, McDonnell SM, unpublished data, 19864991). These cases fall principally into five categories of dysfunction, which are summarized in Table 1. The two most common disorders seen have been classic emission and ejaculation failure, and urinary incontinence during ejac-

Table 1. TYPES OF SPECIFIC EJACULATORY DYSFUNCTION*

| Dysfunction | Percentage of Stallions |
|------------------------|-------------------------|
| Anejaculation | 59 |
| Urine contamination | 36 |
| Premature ejaculation | 3 |
| Azoospermia | 1 |
| Incomplete ejaculation | 1 |

*N = 62 stallions.

ulation. Premature ejaculation, partial ejaculation, and azoospermic ejaculation also have been seen in stallions. These disorders appear to be much less common and are typically transient.

Classic Emission and Ejaculation Failure

Classic anejaculation in horses involves intermittent or continuous failure of emission and ejaculation in spite of normal sexual arousal and persistent mounting and thrusting. In some cases, libido may decline or aberrant sexual behavior may emerge secondary to the ejaculatory disturbance. Typically, persistent anejaculation leads to sour or aggressive behavior as the stallion appears to become frustrated. Some horses eventually lose sexual interest. If the history is not known, these advanced cases are difficult to distinguish from cases of primary libido dysfunction.

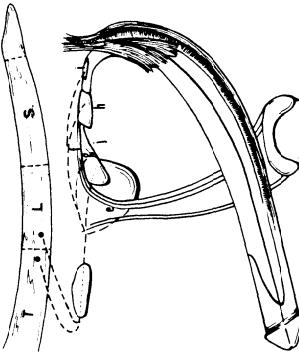
Urine Contamination of Semen

In men, bladder neck incompetence is associated with a condition known as retrograde ejaculation.¹⁰ Men with this disorder experience the sensation of emission and ejaculation, but the semen travels into the bladder rather than through the urethral orifice. Numerous equine clinics have explored the possibility of retrograde ejaculation in horses, but apparently no cases are known in which significant numbers of sperm have been recovered from the bladder of a stallion. Rather, bladder neck incompetence in horses seems to result in seepage of urine during copulation. Contamination can be slight to gross, and urine can precede, be intermingled with, or follow the semen fractions. In horses with persistent slight contamination, viable semen often can be obtained if the stallion can be encouraged to urinate just prior to breeding, although this will not always solve the problem. In our clinic, we have seen several cases in which intermittent or persistent urine contamination of semen was associated with neurologic hind limb deficiencies.

Emission Without Ejaculation

Emission without ejaculation results in a slow dribbling flow, rather than forceful fractionated expulsion, of semen from the urethral orifice. This condition is most commonly seen in men with spinal injuries. We have not seen a stallion in which this has occurred. Emission without ejaculation is the normal outcome of electrostimulation. As in men and some other domestic species, semen obtained by electrostimulation of the anesthetized equid dribbles from the urethra. The semen also varies in composition from that obtained during copulation, suggesting non-

| | |
|-----------------------------------|--|
| Erection | Penis drop due to sacral parasympathetic mediated relaxation of corporal trabecula (a) and refractor penis muscle (c). Erection of the shaft and glans penis due to parasympathetic mediated relaxation of vascular corpora cavernosa (a) and corpus spongiosus (b). |
| Pre-ejaculatory Secretions | Release of small amounts of accessory gland fluids, principally from the prostate, due to sacral reflex mediated contraction of the accessory glands (d). |



| | |
|-----------------------------|---|
| Emission | Release of spermatozoa and accessory gland fluids due to thoracolumbar reflex mediated contraction of the smooth muscle of the ductus deferens (e), ampulla (f), vesicular gland (g), prostate (h), and bulbourethral gland (i). |
| Bladder Neck Closure | Tight closure of the bladder neck due to thoracolumbar reflex mediated contraction of the smooth muscle of the bladder neck (j). |

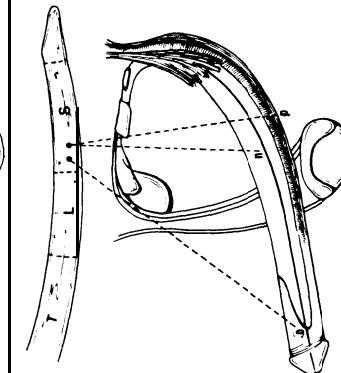
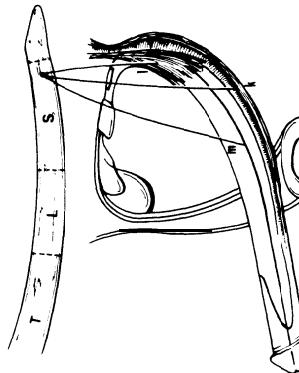


figure 1. Neural and vascular events of sexual response in the horse.

physiologic amounts of fluids expressed from the contributing glands. Semen samples obtained by electrostimulation, either in anesthetized or conscious mammals, often have decreased sperm concentration and total sperm number.

Azoospermia

Azoospermia, or semen void of sperm cells, is rare in stallions. Sperm production or maturation problems usually result in oligospermia. Except in the relatively rare occurrence of bilateral defect or occlusion of the deferent ducts or ampullae, azoospermia has not been reported in the stallion.²⁴ In most cases of suspected azoospermia, we have found that the fluid evaluated as semen was actually clear pre-ejaculatory secretions. In stallions with delayed ejaculation or anejaculation, pre-ejaculatory fluid can accumulate to copious quantities in the collection vessel (in excess of 50 mL).

Premature Emission and Ejaculation

Rarely, some stallions seem to have an abnormally low threshold for flaring of the glans penis, emission, and ejaculation. They may ejaculate before adequate insertion. The cause of this condition is not known. Flaring of the glans penis and ejaculation often can be delayed by using cool water for washing the penis and by deflecting the penis ventrally until insertion.

Mounting and Thrusting Deficits

Emission/ejaculation failure in stallions often is accompanied by signs of musculoskeletal deficits during mounting, insertion, thrusting, or dismount that suggest pain, weakness, or neurologic disorder as the primary problem. Close observation often reveals that the stallion is not thrusting normally or seems distracted or uncomfortable during copulation. Signs suggesting back, hind limb, or urogenital pain during copulation include inadequate coupling of the hindquarters when mounted; failure either to move forward or couple closely to the mare; failure to plant the hind legs firmly and squarely behind the mare; shallow or irregular depth and rhythm of thrusting; and pauses in thrusting, sometimes resting the abdomen on the mare or dangling a hind leg. The stallion may suddenly dismount as though in pain or distracted, often just as ejaculation seems imminent. With repeated mounting, some of these stallions become very tentative and cautious about mounting. Stallions with neurologic disorders typically have difficulty achieving insertion, step on their own hind feet, and are particularly inept at maintaining stability if the mare moves laterally.

Similar awkward or tentative copulatory behavior also is seen in some inexperienced stallions, especially those that seem over-excited in the breeding situation. If these signs are simply a result of inexperience, they usually subside rapidly with successive breedings. If they result from pain or weakness, they usually intensify with the exertion of repeated attempts at breeding.

Examples of physical problems associated with emission/ejaculation failure of this type include degenerative hock disease, back pain, pleuritis, foot abscess, forelimb abrasions typically acquired during training to a dummy mount, stallion ring or associated scarring of the penis, epididymitis, spermatic cord torsion, and testicular or penile lesions. Ejaculatory dysfunction also has been associated with circulatory disease⁶ as well as aortic-iliac thrombosis²³ in stallions. Compromised circulation in the hind limbs is manifest by weakness, apparent pain, and incoordination upon exertion. During breeding, performance diminishes during each mount and with each successive mount. Specific signs include "squatty hocks," "camping under" the mare or dummy, and difficulty dismounting. Such stallions often have difficulty in backing up, especially hurriedly, even when not mounted. Emission and ejaculation appear dependent on functional integrity of the accessory glands, tubular genitalia, and the pelvic musculature. Inadequate circulation to these muscles may adversely affect the emission and ejaculation processes.

Psychogenic Ejaculatory Dysfunction

It is not easy to separate organic from psychogenic causes of ejaculatory dysfunction in any species. In stallions, almost all cases of ejaculatory dysfunction sooner or later include behaviors suggesting a psychogenic component to the problem. In some instances, there is good reason to suspect psychogenic pain or anxiety as the primary or exclusive cause of ejaculatory dysfunction. Examples of cases of specific ejaculatory dysfunction with a strong psychogenic component that we have seen include disturbances of ejaculation following an artificial vagina accident in which the stallion was splashed with the hot water, an explosive mount mare incident, an incident when the rubber band holding a condom in place snapped and hit the stallion, and mishandling of the stallion just before ejaculation. Ejaculatory problems also have been associated with slippery breeding shed floors and use of an unstable breeding phantom. In such instances, the horse typically continues to go through the motions of copulation but seems distracted and does not ejaculate.

THERAPEUTIC APPROACHES

As with sexual behavior dysfunction of all types, an open-minded, patient, and creative approach is critical in finding a workable system

to extend the breeding career of a stallion experiencing ejaculatory dysfunction. The importance of the veterinary clinician's coordination of this process can not be overemphasized. A systematic plan of therapy that includes behavioral and, when necessary, pharmacologic aids, with reevaluation after each step, is more likely to ultimately yield success because it will encourage more sustained and patient efforts from the personnel involved and because each modification resulting in improvement can then be specifically identified. Traditional behavior modification techniques should be thoroughly explored before commencing use of pharmacologic aids.

Traditional Behavior Modification and Management Aids

Perhaps the most useful approach to ejaculatory dysfunction of the types described is to manipulate the breeding environment with the goals of (1) achieving maximum arousal of the horse at the time of mount, (2) minimizing pain and accommodating musculoskeletal deficiencies, and (3) providing maximum positive stimulation to the penis. Table 2 outlines specific measures that have in many cases proved helpful in achieving these goals. The article by Love on semen collection techniques elsewhere in this issue describes several techniques that we have used to assist stallions toward ejaculation. It is of clinical significance that neither erection nor mounting is requisite for ejaculation in the horse. With stallions unable to achieve erection because of damage to the corpora cavernosa penis as well as normal stallions allowed to mount with a flaccid penis, ejaculation can be elicited with manual

Table 2. MANAGEMENT AIDS TO EMISSION AND EJACULATION

To enhance sexual arousal

- Provide prolonged teasing under conditions that yield the highest level of arousal
- Provide natural estrous stimulus and mount mares
- Minimize distractions in the breeding area
- Follow an established routine rich with conditioned stimuli
- Provide encouragement and positive reinforcement

To reduce back and hind limb pain and accommodate musculoskeletal deficiencies

- Provide mount mare of appropriate height
- Position mare down-grade from stallion
- Provide a dummy mount of ideal size and angle
- Collect semen with the stallion standing on the ground (artificial vagina or manual stimulation)
- Treat pain
- Provide lateral support during mount
- Ensure good footing (grass or athletic surface)

To increase positive stimulation to the penis

- Establish pressure and temperature of artificial vagina that yield best response
- Apply hot compresses at the base of penis

stimulation of the base of the penis.¹⁹ Most horses that have difficulty mounting can be taught to ejaculate while standing on the ground, either by use of an artificial vagina or manual stimulation (Fig. 2).²⁰

Pharmacologic Aids

Published clinical or experimental trials evaluating pharmacologic manipulation of emission and ejaculation in horses are limited. The bulk of research has involved attempts to enhance emission and ejaculation by enhancing smooth muscle activity. Almost all drugs known to promote or enhance smooth muscle activity have dose-dependent positive and negative effects on other aspects of copulatory function and libido. Effects of most available drugs vary considerably among individual stallions. For these reasons, most fertility clinics view pharmacologic aids to ejaculation as most appropriately considered after management aids alone have proved unsuccessful.

Classic Adrenergic Agents

Most regimens for treating ejaculatory dysfunction are based on selectively enhancing alpha-adrenergic or blocking beta-adrenergic activity, thereby enhancing smooth muscle contractility. Klug^{6,7} developed a regimen which involves administration of an alpha-agonist (L-norepinephrine, 0.01 mg per kg intramuscularly, 15 minutes before breeding) followed by a beta-antagonist (carazolol, 0.015 mg per kg 10 minutes before breeding). This method was successful in 17 of 24

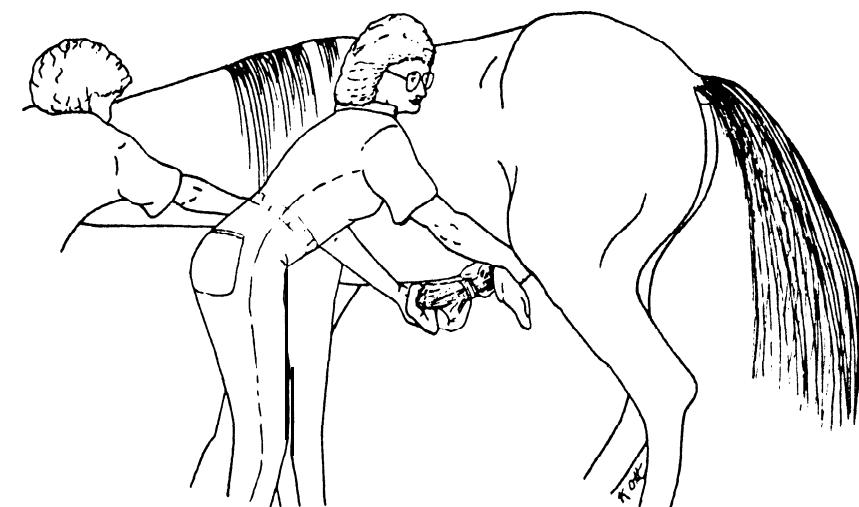


Figure 2. Collection of semen by manual stimulation of the penis in a stallion unable to mount.

stallions suffering ejaculatory failure that had been refractory to management changes and traditional behavior therapy. Both ephedrine sulfate and pseudoephedrine, which directly stimulate alpha- and beta-adrenergic receptors as well as causing release of norepinephrine, have been used to enhance ejaculatory function during copulation.²⁸ The beta-antagonists bunitrolo²⁹ and propranolol and the alpha-receptor agonist phenylpropanolamine (Kenney RM, unpublished data, 1983) have also been tested. These agents typically have had no effect or improved ejaculation on only one or two occasions for each horse.

We recently have used xylazine to induce ejaculation without copulation in stallions that were unable to mount or to ejaculate during copulation? Xylazine has both alpha,- and alpha,-adrenergic effects, both centrally and peripherally but has been viewed as predominantly promoting alpha,-events.¹ In normal stallions, ejaculation occurs approximately 25% of the time after intravenous injection of 0.66 mg per kg with the horse standing quietly and undisturbed. The ejaculate can be collected in a plastic bag attached over the prepuce by a girth strap, as shown in Figure 3. Similar work to evaluate effects of alpha-adrenergic agents on ejaculation during copulation is ongoing in our laboratory.

Tricyclic Antidepressants

Widely used for alleviation of depression, anxiety, and obsessive-compulsive disorders in humans, the tricyclic antidepressant drugs have been known to affect ejaculatory function. Most widely reported are their adverse effects at antidepressant dose-levels.²⁶ Among the side-effects reported by men treated for depression with these agents

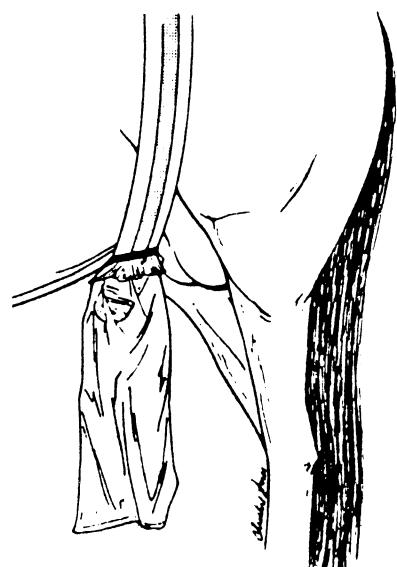


Figure 3. Plastic bag attached to belly girth for collection of drug-induced ejaculate.

are delay or failure of emission and ejaculation, emission without ejaculation (semen dribble), ejaculation without emission (dry ejaculation), and retrograde ejaculation (semen into the bladder due to failure of bladder neck closure). Also reported are effects on ejaculation that may indicate enhancement, including spontaneous ejaculation and orgasm associated with yawning²⁵ or defecation? Treatment of human patients with low doses of tricyclic antidepressants sometimes alleviates delayed ejaculation or anejaculation? The mechanism of action is not clearly understood; however, these compounds and their metabolites promote alpha-adrenergic activity by inhibiting norepinephrine re-uptake.

In horses, imipramine at relatively low doses (500 to 800 mg IV) induces erection and masturbation in both stallions and geldings and also appears to reduce the threshold for ejaculation without copulation in stallions.¹⁶ At this dose, the animal is drowsy if undisturbed. Imipramine (100-500 mg orally, b.i.d.) has appeared to enhance ejaculation during copulation in stallions suffering long-term ejaculatory dysfunction (McDonnell SM, unpublished data, 1991). This regimen also has been useful in treating urine spillage into the ejaculate, presumably by enhancing contractility of the bladder neck during emission.

Prostaglandins

In other species, positive effects of prostaglandins, both PGF-2_{alpha} and PGE, on sexual behavior and ejaculation have been demonstrated. In horses, there has been limited study of the effects of prostaglandins on reproductive behavior. In preliminary work at our facility (Sertich PL and Garcia MC, unpublished data, 1982), 0.02 mg/kg PGF-2_{alpha} administered subcutaneously 2 to 5 minutes before breeding caused muscle weakness that was judged incompatible with safe breeding of the stallion. In other work, stallions treated with similar doses 1 hour before collection of semen apparently exhibited no changes in copulatory behavior.⁹ During the hour following treatment, some of the stallions were observed to have an extended flaccid penis, and in some cases, fluid was dripping from the penis. In recent preliminary trials at our facility, PGF-2_{alpha} at roughly half the dose used in previous studies (0.01 mg/kg IM) induced spontaneous ejaculation in roughly half of the stallions within 10 minutes following treatment (McDonnell SM, unpublished data, 1991). Erection of the penis occurred at least once within an hour following treatment in all treated animals; however, all ejaculations occurred when the penis was flaccid. Moderate abdominal cramping was seen for up to 1 hour following treatment at this dose.

Oxytocin

Oxytocin has been investigated for its role in copulatory behavior. In some species, it has been demonstrated that oxytocin levels rise in association with copulation.; In rats, oxytocin induces a syndrome of

vawning and erection in a nonsexual context? Oxytocin treatment has been useful in some horses with occluded ampullae to enhance smooth muscle action in dislodging sperm plugs (10–20 IU IV in a 450-kg horse, administered after ejaculation and massage of the ampullae per rectum, and immediately before the subsequent mount, repeating the protocol until an ejaculate free or nearly free of headless sperm is obtained; Kenney RM, unpublished data, 1991). In recent preliminary work (McDonnell SM, unpublished data, 1991), we have been unable to demonstrate enhanced ejaculatory function of normal stallions during breeding or without copulation using oxytocin treatments across a broad dose range (0.05 to 0.40 IU/kg).

Anxiolytics, Analgesics, Gonadotropin-releasing Hormone, and Testosterone

In cases of ejaculatory dysfunction, agents that enhance overall arousal often help the horse achieve ejaculation. These include anxiolytic agents. The most thoroughly evaluated for this purpose is diazepam.^{18, 19} We use 0.05 mg/kg (20 mg maximum dose) administered slowly intravenously 5 to 7 minutes before breeding.

If physical pain that may be interfering with sexual arousal or copulatory function is suspected, we typically begin a regimen of pain medication. Phenylbutazone treatment (1-2 g orally b.i.d. for at least 10 days) often results in marked improvement within 10 to 14 days. We find it important to continue treatment for at least 5 to 10 days before evaluating efficacy. In a recent study,²² we found no adverse effects of a 30-day course of phenylbutazone treatment (1 g orally b.i.d.) on semen of stallions. Acupressure, acupuncture, massage, and chiropractic techniques also have been useful in extending the breeding life of some stallions with back pain.

Gonadotropin-releasing hormone (GnRH) has been shown to enhance male sexual behavior via increased circulating testosterone as well as by extra-endocrine (possibly direct central nervous system) effects on sexual behavior.²⁷ We have found a regimen of 50 µg GnRH (Cystorelin, CEVA, Overland Park, KS) administered subcutaneously 2 hours and again 1 hour before breeding can "super-arouse" most stallions. This regimen is typically associated with a doubling of resting testosterone levels.

Testosterone and other androgens have been used to increase sexual interest and arousal, although their use in breeding stallions is controversial because high levels of androgens impair spermatogenesis.¹⁵ In our experience, administration of small amounts of testosterone (testosterone propionate in oil, 50 to 200 µg/kg, SC every other day) is effective in increasing arousal and apparent genital sensitivity in some cases. We monitor circulating levels of testosterone every other day so as not to exceed levels of 4 ng/mL. Androgen treatment can be discontinued, at least temporarily, after the stallion begins to ejaculate regularly. We have used androgen treatment conservatively and have not maintained a stallion on it for an entire breeding season.

SUMMARY

In summary, important events of ejaculation include emission of sperm and the accessory gland fluids into the urethra, simultaneous closure of the bladder neck, and forceful ejaculation of the combined semen through the urethra. Emission and bladder neck closure are primarily alpha-adrenergically mediated thoracolumbar sympathetic reflex events with supraspinal modulation. Ejaculation is a sacralspinal reflex mediated by the pudendal nerve. In stallions, the most common ejaculation disorders are emission and ejaculation failure, and urine contamination of semen. Rare disorders are azoospermia and premature ejaculation. In a large percentage of cases, anejaculation appears to be a result of musculoskeletal disorders or to be psychogenic in nature rather than attributable to specific ejaculatory dysfunction.

Traditional therapeutic approaches for accommodating deficits can extend the breeding life of many stallions. Pharmacologic aids may be useful.

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